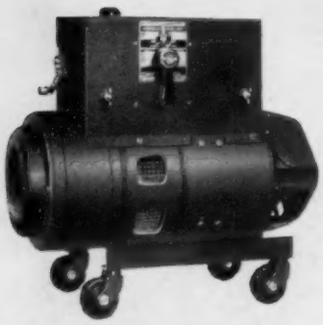
APRIL 1940

WELDING Journal



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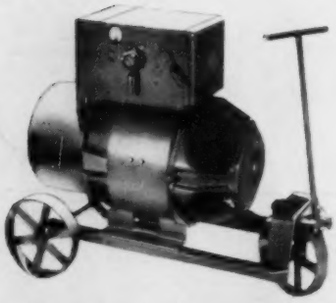

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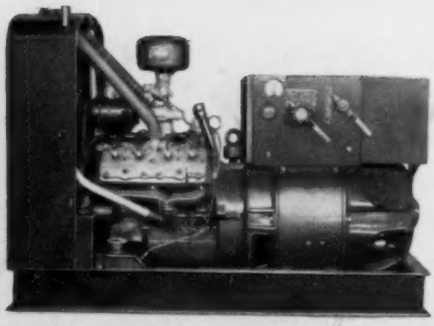

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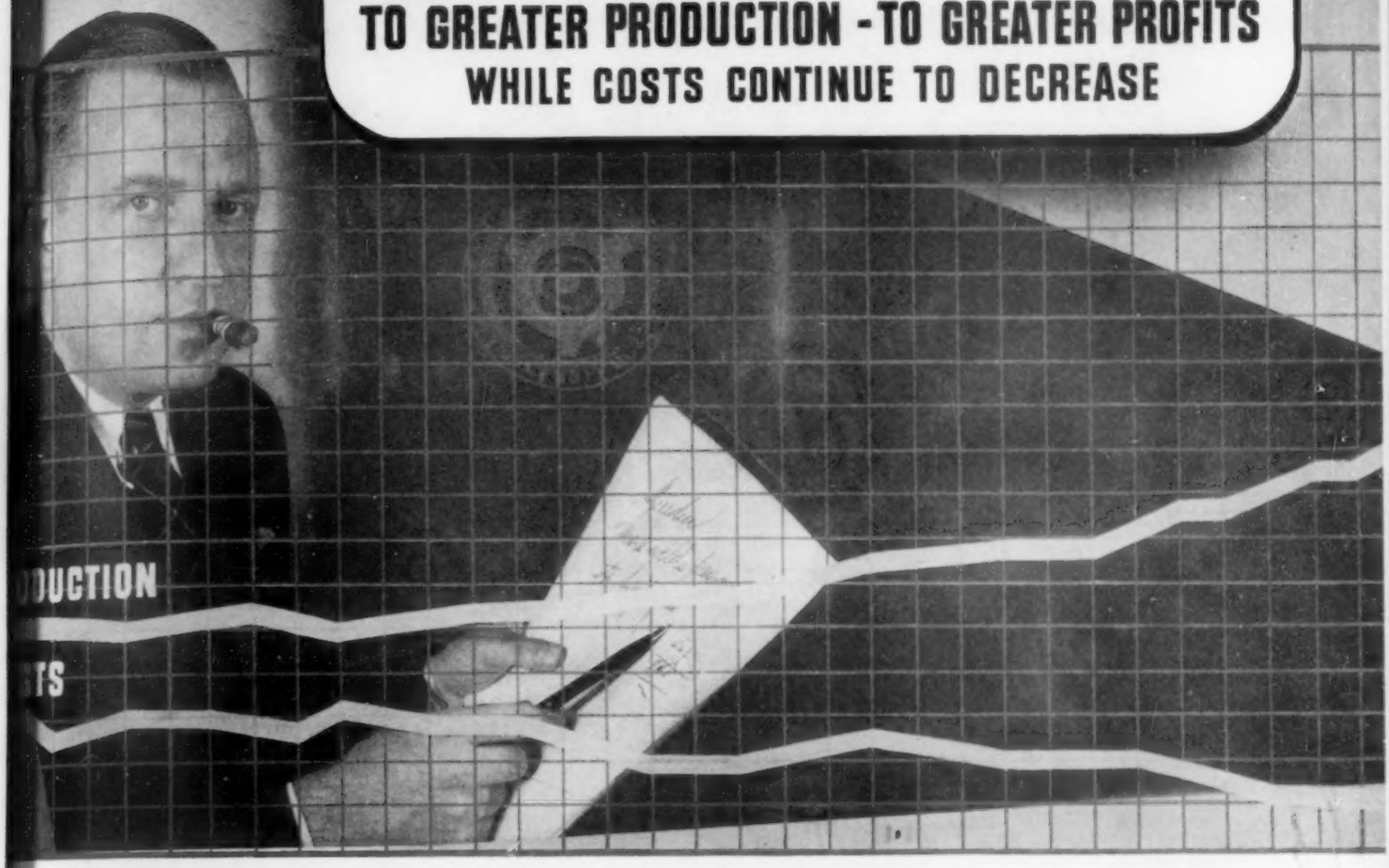

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FLAME-HARDENING from the Standpoint of the Commercial Heat-Treater*

By W. G. HAMILTON†

INTRODUCTION

THE writer represents a commercial heat-treating company, which for a long time has recognized the need for some practical method of supplementing its heat-treating facilities so that it would be in a better position to handle large castings, structures and machine parts which must be finish-machined prior to heat-treating and which by their size and shape cannot be successfully heat-treated by furnaces in the conventional way.

It has been only since the advent of the oxyacetylene flame-hardening process and the practical manner of its presentation in recent years that the problem of locally heat-treating large castings and forgings has been so satisfactorily answered. This comparatively new method is now assisting us materially in successfully handling the ever-growing demands for heat-treating from our trade.

As there have been many exhaustive papers written on the metallurgical phases of the process and the many kinds of ferrous metals which favorably respond to this process of local heat treatment this paper will deal chiefly with the mechanics of the applications, its advantages in certain cases, and how it benefits the customer looking for satisfactory heat-treating service.

DESCRIPTION OF FLAME-HARDENING

Briefly, the flame-hardening process may be defined as a method of employing the oxyacetylene flame or flames for quickly raising the surface temperature of quench-hardening ferrous metals to their respective hardening temperatures and then quickly cooling with a suitable quenching medium.

As have been described in previous papers, there are several ways in which the process may be used, namely: progressive hardening, batch heating and quenching, spinning and progressive spinning. Of these we find that the progressive method of hardening is the most practical for our requirements. It is more flexible, and it minimizes the volume of special equipment required, such as torches and tips, which fact makes for economies that can be passed on to our customers.

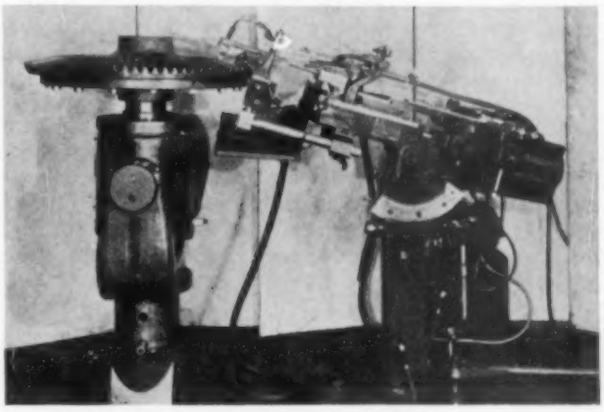


Fig. 1—Gear Hardening Machine

By the use of the progressive method we are able to harden flat surfaces on machine parts, cam shapes for many kinds of machinery, spur, bevel and spiral gear teeth, cylindrical shapes, plungers, bushings, etc. The degree of hardness obtained is largely determined by the carbon content of the metal, the mass of metal beneath the hardened surface and the quenching means employed. In some cases, no quenching is required other than the chilling effect of the cold metal mass beneath the heated surface. The hardness secured will frequently depend on the analysis of the metal combined with the temperature at which the unheated part is maintained; as an example by partial submergence in a cooling circulating water tank, or by directing the quenching streams upon the surrounding surfaces, which in effect will produce the quick cooling or chilling of the heated areas. On low-carbon steels requiring quick heating and quick quenching, higher torch speeds may provide the necessary quick heating and cooling rate required for maximum hardness.

* Presented at Annual Meeting, A. W. S., Chicago, Ill., Oct. 23 to 27, 1939.
† President, Accurate Steel Treating Co., Chicago, Ill.

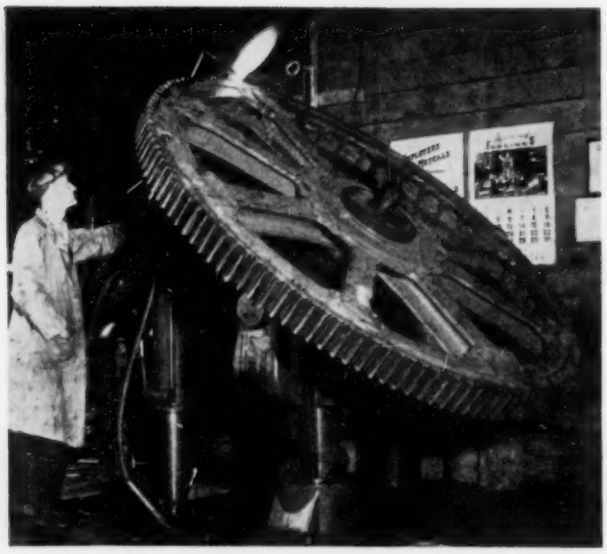


Fig. 2—Large Ring Gear Made by Link Belt Co.

FLAME-HARDENING GEAR TEETH

The method of cooling neighboring areas, we have used many times when flame-hardening gears made from the higher alloys. Water-quenching these steels will invariably produce small surface checks and for this reason the quenching streams of water are directed on the adjacent teeth only.

With the straight carbon steels, no trouble is ever experienced or with a number of other alloy steels.

The flame-hardened gear tooth has met with decided favor for this type of heat treatment and permits, first, machining to exact dimensions and then the subsequent heat treatment without any accompanying distortion; in other words, a tooth with a strong tough core and a hard surface where wear is greatest.

The flame-hardening of all of our gear work is done on our Gleason gear flame-hardening machine.

Figure 1 shows our gear-hardening machine. This machine is fitted up with an oxyacetylene torch equipped with parallel water-cooled tips which, when in operation, are positioned on either side of the gear tooth being hardened. The cooling water is then discharged back of the tips from quenching jets which, with controlled speeds, comprise the component essentials for the progressive flame-hardening method.

These tips are carried along the pitch line of the tooth at a speed sufficient for producing the required hardness and can be adjusted for the various sizes of gear teeth. As they approach the end of the tooth, their speed is automatically increased to compensate for the reducing mass of the unhardened remainder of the tooth which otherwise would become overheated. It is this feature which is responsible for the uniformity of the hardened cross-sectional areas throughout the entire length of the tooth.

In the case of bevel and spiral bevel gears, the tips automatically close together and increase in speed while traveling toward the center of the gear as is required, due to the decreasing size of these teeth. Near the end they again pick up additional speed for the same reason as on straight teeth. This explains why we are able to produce the same uniformity in bevel gears as on spur gears.

In the beginning, I mentioned the need for the flame-hardening process in meeting the ever-growing demands imposed upon the commercial heat treater for handling work which incorporates requirements physically outside and beyond the scope of furnace hardening methods. Realizing this recognized gap in our facilities for general all-around heat treating, we made strides to put ourselves in a position where this class of work has now become a regular part of our standard heat-treating practices and methods.

Some of the flame-hardening operations which are possibly the most popular are those on our gear work. So, in this respect, I wish to call attention to some work now being done for the Link Belt Company in Chicago on our gear-hardening machine described in the foregoing.

Figure 2 shows a large ring gear, made by Link Belt Company. These ring gears, some of which are 88 inches pitch diameter were used in the past with no heat treatment of any kind as it is quite obvious that such would be impossible and impractical after the necessary machine work was done. Consequently, gears used for these purposes would show excessive batter and the teeth would become cupped on their tops after a very short time in service. To have attempted furnace hardening on a gear of this size would have rendered it useless due to distortion. But with flame-hardening of teeth, this is being accomplished most successfully.

These gears are cast from steel having an analysis of 0.30 to 0.35 carbon, 0.80 to 1.0 manganese and 0.30 to 1.50 silicon. On the machined teeth, a consistent average of 60 to 70 scleroscope is obtained while on the cast teeth, 50 to 60 scleroscope. This company has been having these gears flame-hardened for the past one and one-half years, and during this time have found their life greatly lengthened, and instead of the teeth battering or cupping at the tops, a normal wear, such as might be expected, results.

CIRCULAR FLAME-HARDENING MACHINE

Figure 3 shows our circular flame-hardening machine. The design of this machine permits flame-hardening using the progressive method covering widths of various dimensions in similar manner to the gear work and also by the spinning method. This is accomplished by subjecting the spinning part being hardened to sufficient heat so that the entire circumference is quickly raised to

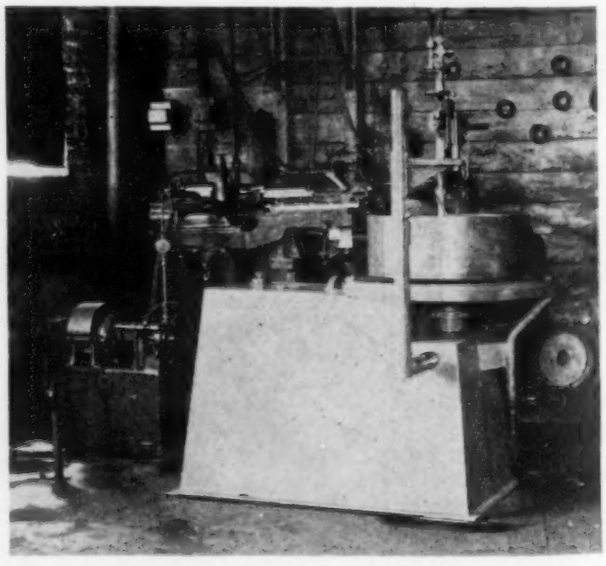


Fig. 3—Circular Flame-Hardening Machine

the critical temperature at which time it is quenched while still spinning.

In the case of the progressive method, the rotation of the table is controlled by a variable speed motor which provides speeds sufficient for circular pieces from 2 inches to 7 feet in diameter.

Figure 3 shows a ring used in connection with a large friction clutch where two hardened bands 4 inches wide on the inside diameter were required. This ring is $8^3/_4$ inches long, $20^1/_2$ inches inside diameter and $23^1/_2$ inches outside diameter, and was made from S. A. E. 4140 steel. Hardness obtained averaged 90 scleroscope and when checking for distortion, a maximum of 0.005 inch was found. In view of the $1^1/_2$-inch walls on this ring, this shows up most favorably. Fame-hardening on this part made possible such advantages as a maximum stock of 0.015 inch for finish grinding and the elimination of a jig costing $20.00 which would have been necessary in the case of the furnace-hardening to maintain the relationship of the finish ground dimensions to the original machined dimensions. However, with selective hardening, necessary drilling and machining were possible following heat treatment.

When flame-hardening a continuous band on any circular part with the progressive method, a zone of metal which is somewhat softer will occur at the completion of the band where it joins into or overlaps the starting point. If it is important that this line, which usually is approximately $^3/_8$ inch wide, not be parallel to the axis of rotation, it can be angled off at any desired degree by raising or lowering the torch while the part is still rotating, making a spiral overlap. The correct positioning of the soft streak was demonstrated on a heavily loaded conical roller hardened to 65 scleroscope on which the softer overlapping line spiralled across the face at 45 degrees. Detection of this line after a six months' service period was impossible as far as any wear or distortion was concerned.

TOGGLE LINKS

Figure 4 shows a toggle link for a die-casting machine. The function of this link is to close and support the dies during the casting of die-castings.

When under load, the knees take the abnormal pressure off the supporting pins. These knees are in turn operated against aluminum bronze shoes which are made up in segments $^3/_8$ inch thick by 4 inches long and $2^1/_2$ inches wide. Their purpose was to absorb the wear which could then be replaced but when the toggle links had been in service for a time, wear occurred on the links as well as on the shoe.

As the material in these links was of an S. A. E. 4140 steel, these knees were flame-hardened with very favorable results with readings as high as 85 scleroscope being obtained. As can be seen, these were all previously machined to finished size both on the outside of the knees and the inner pin fits, and when such were inspected after hardening, no distortion was found so the parts again were reassembled in the machines without any further work. This completely overcame the trouble and made these machines function as originally designed.

We have from time to time received into our plant such things as cast-iron plungers where specified areas are to be hardened and various types of internal cams where only the loaded sections are to be hardened, all of which readily lend themselves to this particular method of local heat treatment.

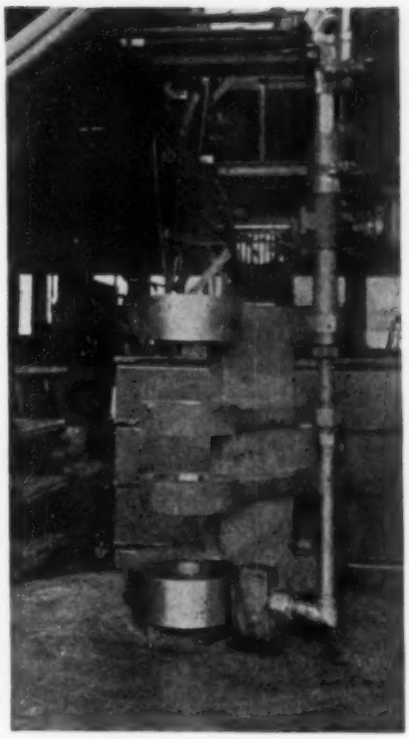


Fig. 4—Toggle Link for Die-Casting Machine

CONCLUSION

Being a commercial heat-treating company, whose facilities are rather broad in scope, we are primarily interested in the *heat-treating* of steels, and our chief interest is not in stressing any particular method for the sake of that method, but, rather, in selecting the one which will give us the best physical properties in the various types of steels for the services intended.

To us, flame-hardening is only considered as another method of heat-treating, and one which has the capacity for meeting certain requirements which otherwise might be difficult, if not impossible.

Flame-hardening in the commercial heat-treating companies can be likened unto welding in the shops of the structural steel fabricators. When properly employed, the structures are definitely better but when used just for the sake of welding, then some of its advantages become very expensive practices. So it is with flame-hardening, and for this reason we make a very careful analysis of the work coming into our plant so that at all times the proper methods will be used.

In conclusion we wish to take this opportunity of expressing our thanks and appreciation for the assistance rendered on many occasions by our welding supply company, whose services we feel have been most invaluable when needed.

A Handy Clamp for Aligning Pipe

How to Make a Clamp for Holding Pipe in Line During Tack-Welding Operations

By T. F. LEACH*

ALMOST every small welding shop is from time to time called upon to make welds in steel pipe. In some instances, where small sections only are being joined, this can be done on a bench supported by simple V-blocks. Where long lengths of pipe are involved, however, it is sometimes easier to clamp the sections so that the two ends of the pipe will be properly spaced for welding.

In the accompanying sketch is shown the plan for making a clamp, for aligning pipe, which involves simple and easily obtained materials and little work on the part of the welding operator.

CLAMP CONSTRUCTION

This clamp consists primarily of two parallel plates which are connected by welding a section of angle iron sufficiently long enough to support the ends of the pipe about 6 or 8 inches back of the joint. The dimensions on the plan are for a clamp to be used on pipe up to about 3 inch diameter. If larger sizes of pipe are being used, it will be necessary to increase the sizes of the angle iron, of the base plates and possibly also of the chains for holding the pipe in place.

The angle iron is first welded across the face of the two plates. The $^3/_8$-inch eyes in each end of the plates

This Modification of the Jig Shown in the Sketch Uses Two Special "C" Clamps in Place of the Chains

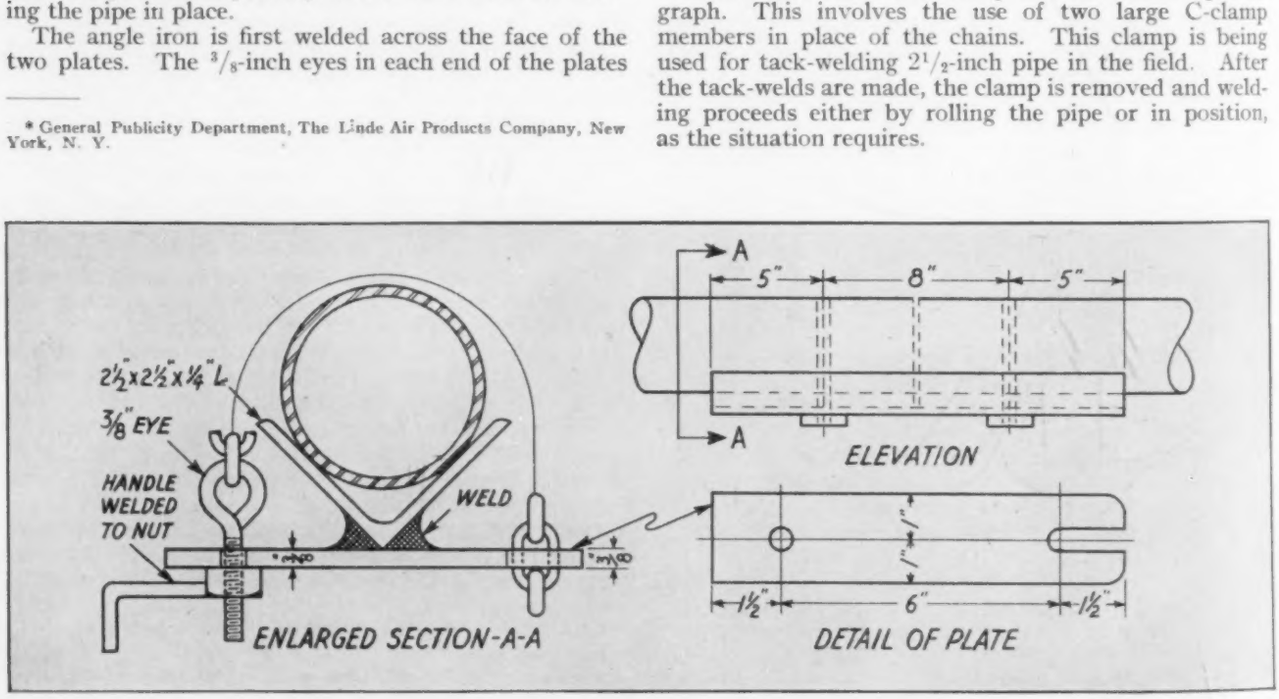
are then inserted in the holes and the chains drawn over the pipe and slipped into the slots so that the links bear on the underside of the base plates. Nuts are threaded over the eyes. A small piece of welding rod can be welded onto each nut to form a handle for quick operation of the clamp.

QUICK ADJUSTMENT

It is a simple matter to adjust this clamp on the ends of two pipes. The pipes can be spaced by laying an $^1/_8$-inch or $^1/_{16}$-inch diameter welding rod across the two arms of the angle iron and butting the pipe up against it, then fastening the aligning clamp in place so that the proper space is thus provided. The welding rod can then be removed and tack-welds made on three places in the pipe circumference.

A modification of this clamp is shown in the photograph. This involves the use of two large C-clamp members in place of the chains. This clamp is being used for tack-welding $2^1/_2$-inch pipe in the field. After the tack-welds are made, the clamp is removed and welding proceeds either by rolling the pipe or in position, as the situation requires.

* General Publicity Department, The Linde Air Products Company, New York, N. Y.



This Sketch Shows Construction Details of a Simple Clamp for Aligning Pipe

DESIGNING CONSTRUCTION

Machinery for Production by Welding*

By H. C. HETTELSATER†

THE construction machinery builders have made rapid strides in the introduction of electric arc welding as a production method during the last five years. The general result obtained by those who use this method widely in their design was to secure very marked reductions in the weight and also in the cost of producing this class of equipment. In some cases the cost reductions were of sufficient magnitude to enable selling prices to be reduced to a point where completely new markets were opened up.

The weight reduction also enabled these machines to be more easily transported. One very noticeable effect was that County Road Commissioners found that the welded type of machine with its lighter weight could be transported on light weight trailers on secondary roads where the load-carrying capacity of bridges was too low to permit transportation of the older and heavier machines.

Excavating machines, which include shovels, draglines and crawler cranes, have been redesigned to take advantage of the benefits to be derived from the introduction of arc welding as a production process. Some typical examples of how this has been accomplished together with a discussion of the design method used will be discussed in this paper.

There are a number of factors involved in the designing of excavating machines which are not present in stationary structures. These include among others the necessity for designing to obtain a minimum of weight, especially in the boom and bucket and also the ability to withstand very severe impact stresses. These conditions forced the designers to search the market for materials which possess physical properties greatly in excess of the materials which had previously been used and led to a general adoption of the low-alloy structural steels for use in the structural parts of the excavators. This steel

* Presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.

† Chief Engineer, Excavator Division, Harnischfeger Corp., Milwaukee, Wis.

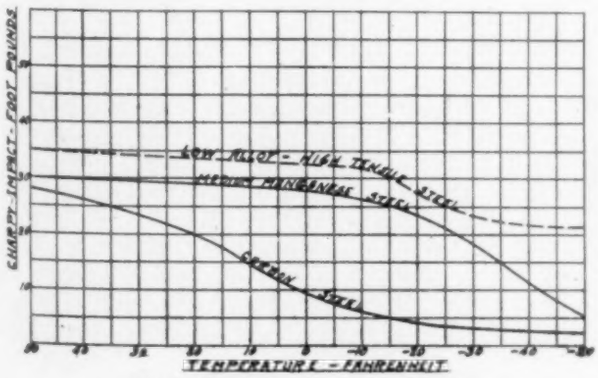


Fig. 1—Charpy Impact Values of Steels

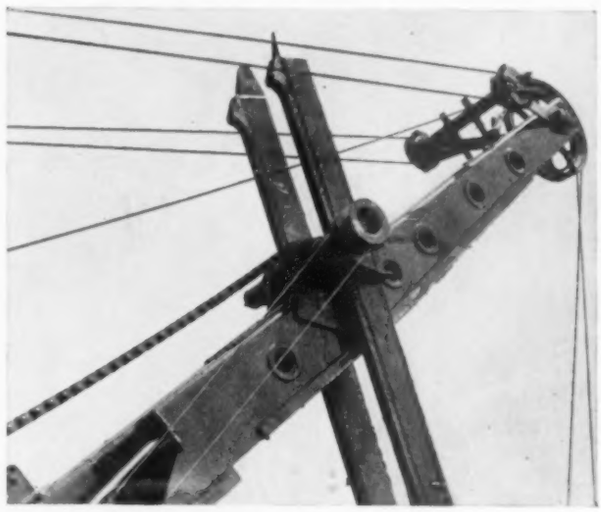


Fig. 2—Shovel Boom

also found very general acceptance for use in booms, dippers, dipper handles and dragline buckets.

There can be no general rules laid down as to the best grade of steel for each application since it is necessary for the designer to select a grade of steel which suits the specific requirements of his design and which has high enough physical properties to enable the parts to withstand the stresses imposed upon them. For shovel booms and dipper handles the principal requirements are that the steels have high yield point, high ductility and resistance to shock loading and also that they be readily weldable. The steels which are selected for dippers and buckets must have the same qualities as enumerated for booms but in addition must be able to withstand severe abrasion.

Mild steel has a very definite place in this type of equipment and is very commonly used in the main upper revolving frame of the machines and also in the lower structures. In most of these parts there is relatively small advantage to be gained from the use of alloy steel, since the metal thicknesses required for rigidity will in most cases determine the sizes of the sections selected. There are, however, certain portions of the lower structure, particularly such as the axles and crawler frames, where it has been found advantageous to use alloy steels. These parts are subjected to severe bending and impact stresses and, therefore, the use of steel with a high yield point as well as high tensile strength will result in considerable weight savings and also greater resistance to impact than would be possible with carbon steels.

There are two general classes of structural alloy steel which have been found to be suitable for electric arc

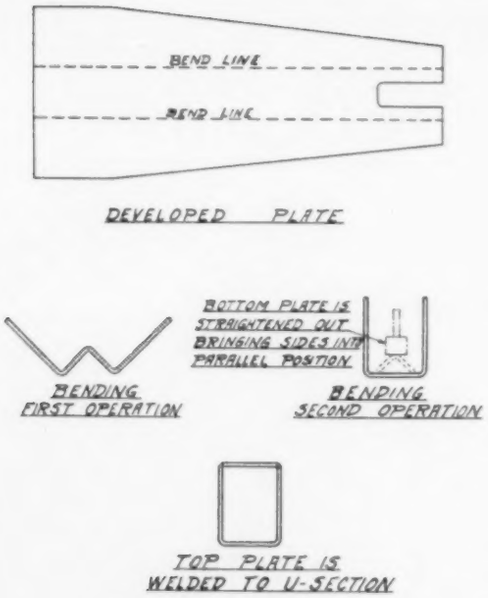

BEND LINE
BEND LINE
DEVELOPED PLATE
BOTTOM PLATE IS STRAIGHTENED OUT BRINGING SIDES INTO PARALLEL POSITION
BENDING FIRST OPERATION
BENDING SECOND OPERATION
TOP PLATE IS WELDED TO U-SECTION

Fig. 3—Methods of Fabrication

welded excavators. The first of these is Medium Manganese Steel which has approximately the following chemical composition:

Carbon	0.35 max.
Manganese	1.25 to 1.70
Phosphorus	0.04 max.
Sulphur	0.05 max.
Silicon	0.15 to 0.30

The exact chemical composition of this type of steel is varied by the various steel manufacturing companies but regardless of the chemical composition, the physical properties should be in accordance with the following minimum values:

Tensile strength	80,000 per sq. in.
Yield point	50,000 per sq. in.
Elongation in 8 inches	$\frac{1,500,000}{\text{T.S.}}$
Reduction in area	55%
Charpy impact value	35 ft.-lb. at room temperature

This type of steel is especially suitable for use in parts such as shovel dippers and dragline buckets which are subjected to considerable abrasion and also to rather high tensile stresses. This steel, however, has less resistance to impact than other grades of alloy steel and is, therefore, not so well suited for booms and other main machine parts.

The second general grade of alloy steel which is most generally used for highly stressed structural members is what is known as Low Alloy—High Tensile Strength Steel. The chemical composition of this grade of steel, as produced by the various steel companies, varies so greatly that it is difficult to set up any one set of specifications covering the chemical composition. However, all of the steel companies agree in holding the carbon content of this class of steel to range between 0.10 and 0.20. The minimum physical properties which are generally obtainable are:

Ultimate tensile strength	65,000 to 75,000 lb. per sq. in.
Yield point	50,000 min.
Elongation in 8 inches	20% min.
Reduction in area	55% min.
Charpy impact value	35 ft.-lb. at room temperature
Endurance limit	45,000 lb. per sq. in. min.

In designing parts built from alloy steels, it is necessary to design so that stresses fall within the allowable tensile strength and also give consideration to the impact resistance of the material, not only at room temperature but also at temperatures which may run as low as from 30 to 40° below zero, Fahrenheit. In order to meet this condition a considerable amount of research work has been done in the last year by the various steel manufacturing companies in an attempt to improve the impact resistance value of these alloy steels at the lower temperatures.

It has been found that down to at least −125° F. the strength, elastic properties and endurance limits of steels are not materially affected, but the drop in the notched-bar impact values may, and frequently does, amount to as much as 90% of the values at room temperature. A full realization of this fact is of great importance to the designer of welded excavators which are often called upon to operate at temperatures as low as −40 to 50° F.

Figure 1 shows a chart in which the Charpy impact values are plotted against temperatures for carbon steel and also for the two general grades of structural alloy steels which have been discussed previously. This chart is not intended to show the maximum values which can be obtained but is given to show minimum values which have been obtained in a series of tests of materials in each class which was produced by various steel producers. You will note a very marked difference in the Charpy impact value of the low-alloy high tensile steels as compared with the medium manganese steel group, especially below −30° F. At this point the high tensile type of steel curve flattens out, and the medium manganese curve is sloping sharply downward. This fact has to a great extent influenced designers in adopting the low alloy—high tensile type of steel wherever possible and in using

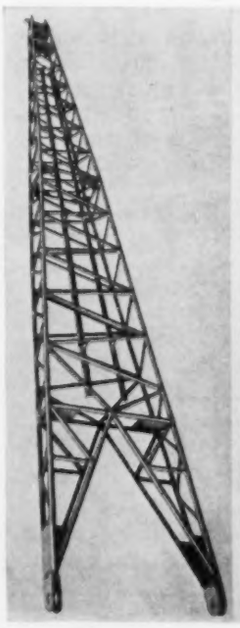


Fig. 4—Boom of Pipe Construction

Fig. 5—Testing Booms

the other grades of steels only where ability to withstand abrasion is a predominant factor. A combination of low carbon and relatively high nickel content in the steel has been found to be very beneficial in increasing the Charpy impact values at the lower temperatures.

It is, of course, necessary when using alloy steels possessing very high physical properties to also select a welding electrode which will produce welded joints having physical properties equivalent to the parent metal. On this account it has been my practice in designing excavating equipment to use high strength alloy steel welding electrodes for welding all parts which are made from alloy structural steels.

Another factor which is of vital importance is the endurance limit of the steel which is selected. In excavating machinery the various parts are subjected to a great amount of vibration and to repetitive shock loading. It has been found that the low alloy—high tensile steels possess a fatigue or endurance limit of about 40,000 lb. per sq. in. as compared with a corresponding value of 27,000 lb. per sq. in. for mild steel.

In order that full advantage may be taken of the possible economies which may be effected by the use of arc welding, it is often necessary to radically change the method of framing the welded part as compared with the conventional methods employed in riveted or cast structures. This usually results in the use of bent plates which, if properly designed, will reduce the number of welded joints. This will not only produce a stronger part but will also reduce the welding time and the cost. This type of design is illustrated very well in the shovel boom shown in Fig. 2.

Fig. 6—Boom After Failure in Test

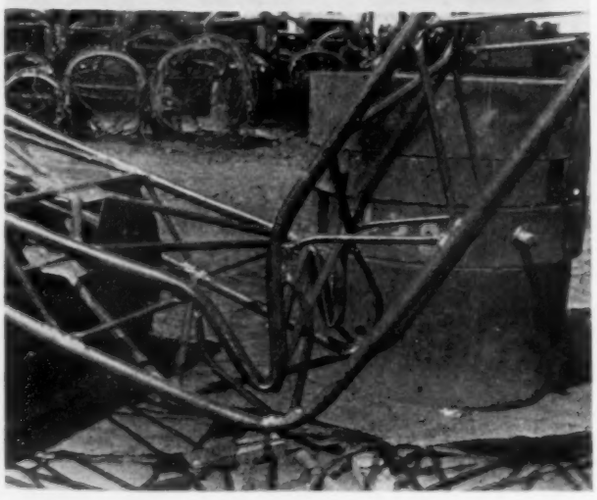


Fig. 7—Close-Up of Failure

Fig. 8—A Boom in Which Chords Are Alloy Steel Angles

The main section of this shovel boom is a box made from one-half inch thick low-alloy—high tensile steel. The entire box section is made up from one main plate which is bent longitudinally to form three sides of the box section. After the plate has been bent into the U section and has been stiffened by suitable diaphragms, the box is closed up by the addition of a bottom plate which is welded with two longitudinal seams.

A shovel boom of this general design built from alloy steel has been built which weighs approximately 30% less than a mild steel riveted boom made in a box section with corner angles. The alloy steel boom had an equivalent calculated strength and at the same time had greater resistance to fatigue stresses due to the higher physical properties of the material used.

Figure 3 illustrates a method by which box section beams or other members can be fabricated. This method applies particularly to sections in which the depth is greater than the width. In such cases it is impossible to complete the bending in two operations on account of lack of clearance for the die block when bending the corners. In this method the first step is to bend the corners at right angles to the bottom plate, and a reverse bend is placed in the middle of the bottom plate. This leaves ample clearance for the die block. The center bend is straightened out in the last operation, resulting in a "U" section, to which a top plate is then welded, making a box section.

A large number of welded dragline and crane booms have been built which have proved commercially successful. There have been a number of types of designs used, one of them being the all-pipe construction such as illustrated in Fig. 4.

In this type of boom the main chord members as well as the lateral bracing members are of standard pipe size tubing. A boom of this type is usually lighter than a boom designed for the same load-carrying capacity made

Fig. 9—Upper Section of Alloy Steel Boom

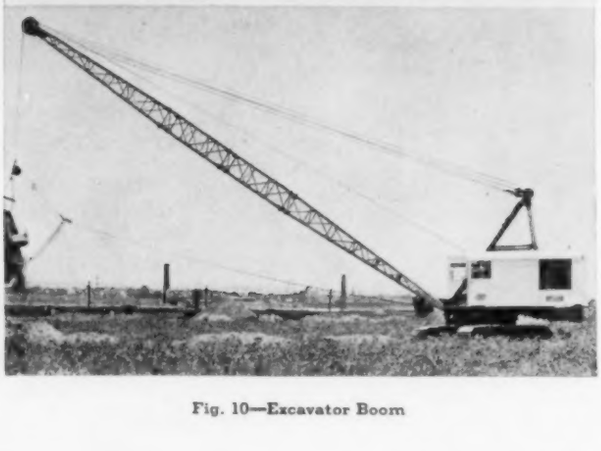


Fig. 10—Excavator Boom

from structural angles in place of tubing. The tubing sections are the most economical in compression members due to the symmetry of the section. It is also possible to make the welded connections between the lateral members and the chords without the use of gusset plates, except at the top and bottom where it is necessary to drill holes for pin connections.

Some interesting tests were recently conducted to determine experimentally whether or not an alloy steel tube boom could carry heavier loads than a carbon steel boom built with the same size of sections. It was found that the safe load which could be carried on the alloy steel boom was practically in direct proportion to the yield point of the material which was used. In the boom which was tested, the carbon steel tubing which was used had a yield point of 35,000 lb. per sq. in. and the yield point of the material used in the alloy steel boom was 50,000 lb. per sq. in.

Figure 5 illustrates the method of making this test. The boom was raised to a high angle so that the load was being carried at about 10 feet from the center of rotation of the excavator. Test weights were then hung on the load block and the loading was increased gradually until the failure occurred.

Figure 6 shows the boom immediately after failure had occurred. The failure occurred at a point about one-third of the distance up from the boom foot, and was the result of a combination of direct compression and bending stresses. The dead weight of the boom caused a downward deflection in the boom, and when the heavy compression stress was applied, this deflection was increased to a point where the stresses exceeded the strength of the material, and failure resulted.

Figure 7 shows a close-up view of the boom at the point of failure. You will note that the tubing bent nearly double without breaking open showing that the tubing possessed very good physical properties. A very close inspection of the welds showed an absence of cracks in any of the joints, which showed that the welds in this case were as good as the parent metal.

An alloy steel tubing boom which was built using exactly the same size of tubing as those used in the carbon steel boom was then tested in exactly the same manner and a similar failure occurred when this boom was loaded 45% higher than the carbon steel boom. These figures check very closely with the percentage difference between the yield point of the two materials.

In analyzing these results we see that this was a typical compression failure due to the members of the boom being stressed to a point where they deflected enough to produce a stress in the members in excess of the elastic limit of the material. It is a well known fact that the modulus of elasticity of alloy steels and of carbon steels are the same, namely 29,000,000. This means that a weight on a given section will produce the same amount of deflection on all steels unless the weight produces a stress in excess of the yield point of the material. The higher the yield point of the material, the greater amount of deflection the steel will stand before taking a permanent set. In applying this principle to the design of booms it will be recognized that an alloy steel boom which is designed to take loadings which are increased in proportion to the yield point of the material, will deflect farther than a carbon steel boom of the same section but will not take a permanent set and, therefore, will be safe for the increased loading.

Another type of welded alloy steel boom which has been proved successful and which has produced outstanding weight economies is one in which the chord members are made of low alloy—high tensile steel angles and the lateral members are made of alloy steel or carbon steel tubing. A boom of this type is illustrated in Fig. 8.

This boom is made up in four sections and is so designed that the length can be varied by removing or adding sections in the center of the boom. The weight of this boom in a 70-foot length is only about 20% heavier than a riveted aluminum boom which was built a few years ago to carry the same loading. This type of boom weighs approximately 40% less than an alloy steel boom with riveted connections which was recently built. This is a very important factor from a commercial standpoint since it is possible to obtain a very substantial saving in the cost by building a boom of welded alloy steel in place of aluminum which costs at least ten times as much per pound.

Figure 9 shows a close-up of the upper section of the boom and illustrates the type of construction used. The lateral members which are of tubing are welded to the toe of the chord angles. The diagonal diaphragm members are also made of steel tubing and are fitted into the inside corners of the chord members.

Figure 10 shows this type of boom applied to an excavator and gives the general proportions as compared with the machine. The light weight of the welded boom has increased the live load capacity of this machine by one-half yard.

The designing of the main revolving frame for an ex-

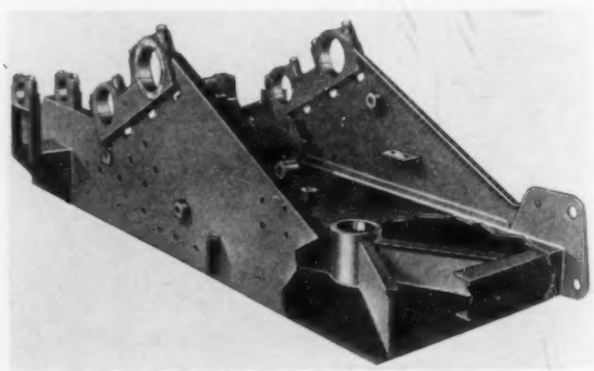


Fig. 11—Revolving Base Plate for Excavator

cavating machine presents some very interesting problems and gives the designer an opportunity to make some very substantial savings in weight and cost as compared with cast steel frames which were generally used before the advent of arc welding as a production process. In order that substantial savings in weight and cost may be realized, it is necessary for the designer to attack this problem with an open mind and that he be willing to deviate from the conventional lines of procedure in developing his design. This is illustrated in Fig. 11.

Figure 11 shows a revolving base plate for an excavator. The conventional type of design which has been generally used in the past has been to make a flat bed plate with machined pads for assembling the side stands and other machinery supporting members. These side stands were bolted to the bed plate and were also tied together and braced with separators. In the welded design the bed plate, the side stands and separators are framed into one integral part. One main plate is bent into a trough section and this plate forms the bottom plate of the bed plate and also the side plates for the side stands. The bearings for the vertical shafts which are journaled in the base plate are made from rolled steel rounds and are welded to the bottom plate and are also securely braced laterally by diagonal and cross members which are welded to the bottom plate. The top cover plate of the bed plate is then laid on top of the diagonal members and is welded to the side stands and to the front and rear cross members. The last operation is to plug weld the top plate to the bent flanges on the top of the diagonal members.

The main horizontal shaft bearings are carried in solid billets which are welded to the side stand plates. The side stand plates are bent over at the top and are also securely braced sideways to afford rigidity to the entire frame. The side stands must be securely braced to withstand any side strains which are imposed by the machinery and it has been found that a very economical method of providing this rigidity to the side stands is by flanging the main plate along its upper edge. It has also been found practical and economical to use plates bent into either a "U" shape or angle shape to provide lateral stiffness. By this method a box section can be formed with only two longitudinal beads.

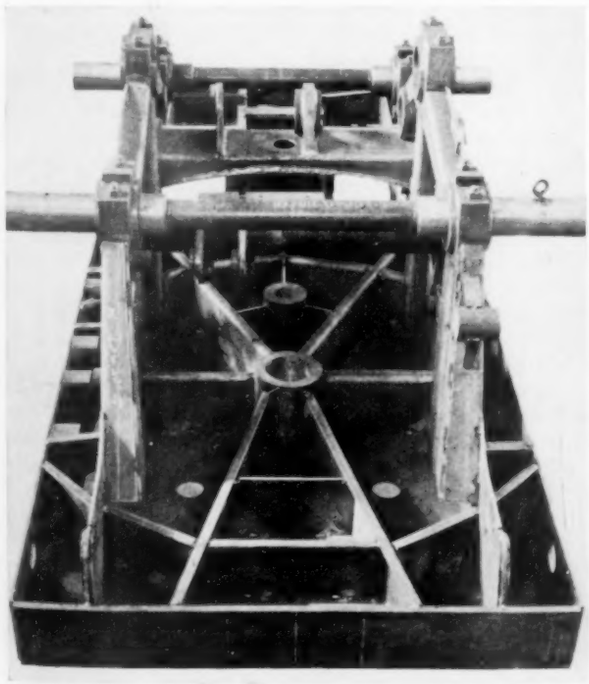


Fig. 12—Partially Finished Revolving Frame for a 2½ Yard Excavator

Figure 12 illustrates a partially finished revolving frame for a 2½-yd. excavator. In designing this frame it was found that it was not feasible to utilize the design described previously due to the excessive width of the plate which would be necessary to form both the side stands and the bottom of the bed plate. Therefore, this design was worked out so that the bottom plate was flanged at the sides to form the side members of the main bed plate. The side stand plates were then attached to the bottom plate and the entire structure was securely tied together by cross members and diagonal stiffeners. These stiffeners were placed in the proper position to distribute the loads over the roller track. The main vertical shaft bearings are carried in bearings which are fitted in the round bosses which are shown welded to the bottom plate and also to the lateral members.

A base plate of this character is assembled and welded in a welding fixture which is designed to accurately locate all of the main shaft centers, and machinery locating points. The bosses for the vertical shafts are located on pins set in the base plate of the welding fixture. The two main shafts which are shown serve to locate the main drum shaft centers. These shafts are carried in the welding fixture and serve not only to locate the shaft centers but also to prevent undue distortion in the side stands during the welding operations.

Figure 13 illustrates the finished revolving frame and shows the manner in which the boom foot sockets are welded to the front part of the frame. This also illustrates clearly the manner in which the side stands are constructed in order to afford the greatest amount of rigidity possible.

Aside from the weight saving which is gained in the use of arc-welded steel in this type of machinery frame, there are very material savings which can be realized in machining and in assembling the machine. Inasmuch as the base plate, side stands, and cross separators are all made into one integral piece, there are no machined surfaces needed for joining these parts together. This permits machining of all of the bearings and other machinery locating points being done in one setting and assures greater accuracy and freedom from misalignment of parts due to loosening up of connecting bolts.

This principle of combining as many parts as possible into one unit welded part has been responsible for some of the greatest savings which have been realized by the introduction of arc welding to excavating machines.

Figure 14 shows a lower structure or carbody with the track and gear and roller track in place. In this particular structure the main carbody frame is a unit welded piece and the track frames, which are also of welded steel construction, are bolted to the main frame. In working out the design of this frame the designer deviated radically from previous practice on frames of this character which had usually been of cast-steel construction. The frame has been reduced to its simplest elements whereby the main vertical load over the roller track is carried on a barrel section which rests on box type axles projecting from one crawler frame to the other.

The center gudgeon is carried in a central barrel shaped section which is held in place by H-beams which are welded to the inside cylinder and also connected to the large cylindrical section. This type of construction is simple and provides for accessibility of all of the welds as well as a direct transfer of the loads from the roller track to the crawler frames.

Figure 15 illustrates a slightly different design of car-

Fig. 13 (Top)—Finished Revolving Frame for Excavator

Fig. 14 (Center)—Carbody with Track, Gear and Roller Track in Place

Fig. 15 (Bottom)—A Different Type of Carbody

body in which the center section and the axles are constructed approximately as shown in the previous cut but the crawler frames in this case are welded to the axles so that the entire carbody and crawler frames become one integral part. In this particular case the axles are formed from a heavy plate bent into a "U" section and closed up by one bottom plate. This makes a very rigid structure which can be produced with a minimum amount of welding. The axles and crawler frames are both made from low-alloy high tensile steel and are welded with high-tensile steel electrodes.

The design fundamentals which must be employed in designing welded excavators are in many ways similar to those which must be employed in designing a similar piece of equipment for casting or for assembly by riveting. By this I mean that the stresses must be determined in a similar manner and that the design must have sufficient strength and rigidity to withstand all of the stresses imposed upon it.

There are, however, a large number of new problems which must be given full consideration by the designer of a welded excavator which are peculiar to this type of fabrication.

Consideration must be given to the assembly of the welded part to be certain that all welds are made accessible and that they can be positioned so that sound weld metal will be deposited. Wherever possible the design should be such that beads can be laid in a downhand position and joints should be designed so that symmetrical sections can be used wherever possible.

Lap joints should be avoided if possible since they usually result in eccentric loading on the weld and also result in excess metal being used which is of no value in producing greater strength. In this connection it has been found to be good practice to utilize bent plates construction wherever possible since this results in the greatest economy of material and it also reduces the amount of weld metal which must be deposited.

Rolled structural shapes also possess many advantages and it has been found that they lend themselves very well to welded construction, especially where the shape of the part is such that the welded connection can be made to the toe or flange of the section, and overlapping of metals can be avoided. In such case it is, of course, necessary that the part be so designed that the weld metal will fully develop the strength of the main section, and if alloy steel is used, the welding electrode which is selected must produce a weld which has physical properties equal to those of the parent metal. This must not be limited only to yield point and ultimate tensile strength alone but must also be a metal which has equivalent shock resisting qualities at normal as well as subzero temperatures.

Frequently, the designer, when faced with a problem of designing a structure for welding, has a fixed picture in his mind of that same structure which has previously been produced by the use of castings or riveted construction. As a result he is prone to design the welded part similar in shape and general characteristics to the part previously used. Usually he has not achieved the best results from an economical standpoint if this is done, and it will be found that his design will involve too many compromises to be an economic success. To overcome this tendency the designer must think not only of the design of a particular joint in a structure but must consider the structure as a whole and work out a method for producing the complete machine or framework which will be the most economical to produce as a welded structure without regard to any preconceived notions as to what the machine should look like.

EQUIPMENT for PULSATION WELDING

Broadens the Field of Resistance Welding*

PART II

By H. C. COGAN† and RALPH S. PELTON‡

THE first pulsation spot weld was made with existing conventional equipment. Although much of the modern resistance welding equipment is suitable for pulsation welding, there is much existing equipment not adapted to such use. This article is devoted to a study of the equipment necessary for pulsation welding, and besides showing what type of equipment is most suitable, will show how some other types of equipment may be used. The type of current interrupter used is important and will be discussed along with water cooling of the electrodes, and means of obtaining longer periods of pressure dwell.

It may be well to repeat the definition: Pulsation welding is a resistance welding method wherein the welding current "or heat" is applied repeatedly for the making of a single weld, or simultaneous welds, in parts clamped between electrodes at rest when a single like impulse of the same current is not sufficient to produce the desired weld.

CURRENT CONTROL

The usual resistance welder is fundamentally a machine tool housing a transformer capable of delivering high current with means for operating electrodes to clamp the parts to be welded and push them together while at welding temperature. Such equipment is operated from an A.C. power supply, and when any large amount of power is demanded frequently for very short periods of time, a real switching problem exists. Such a service is demanded of the interrupter when resistance seam welding by the common method where overlapping spot welds are produced by passing the parts between welding rolls or wheels. A very similar service is demanded of the current control equipment for pulsation welding. The main difference is that in the latter case means must be provided to deliver a certain number of impulses, or pulsations, of power and then stop.

Non-synchronous pulsation welding controls provide some advantages over the conventional single-current impulse welding, but lack many of the advantages which can be gained by the use of synchronous controls for pulsation welding. The non-synchronous controls are sometimes purchased because of their low initial price, but are not recommended. If non-synchronous control is to be used, an ignitron contactor should always be used in place of a contactor with moving parts because the ignitron contactor is quiet and is capable of operating at high speeds without distress. The timing of these non-synchronous controls can be done by means of a limit switch and multiple point cam or by means of a separate non-synchronous tube timer, such as is shown in Fig. 2. When these separate tube timers are used, three dials are required: one for the "weld period" during which the current is intermittently applied to the welder; a second dial for the "heat period" to determine the length of each current flow interval; a third dial for the "cool period" to determine the duration of the "off" period before the current is repeated.

Any non-synchronous control, however, causes transients and direct-current components in the power supply line which result in greater current demand, greater line voltage fluctuation and increased transformer heating. This means that they can be used successfully only where the current flow time is long enough to average out the transient effect, and where the off periods are long enough to allow sufficient time for cooling and for the transformer flux to decay. Because of the greater amount of

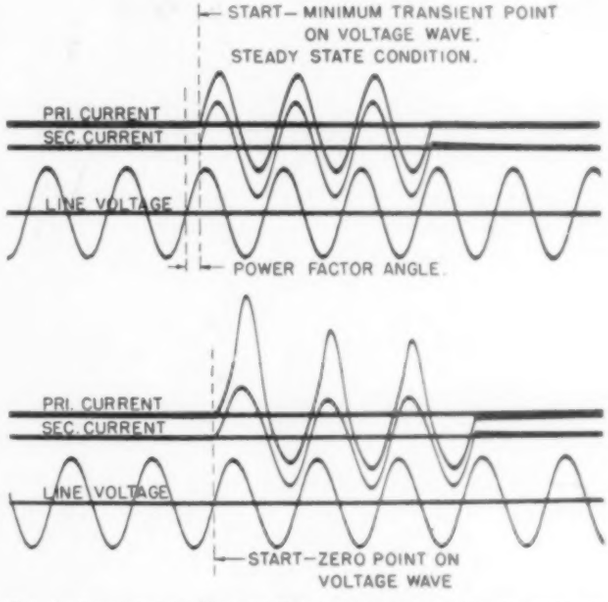


Fig. 1—Oscillograms Showing Results of Switching Transformer on at Different Times on Voltage Wave

* This is one of a series of articles being sponsored by the Resistance Welder Manufacturers' Association.

† Chief Engineer, National Electric Welding Machines Co.

‡ General Electric Company.

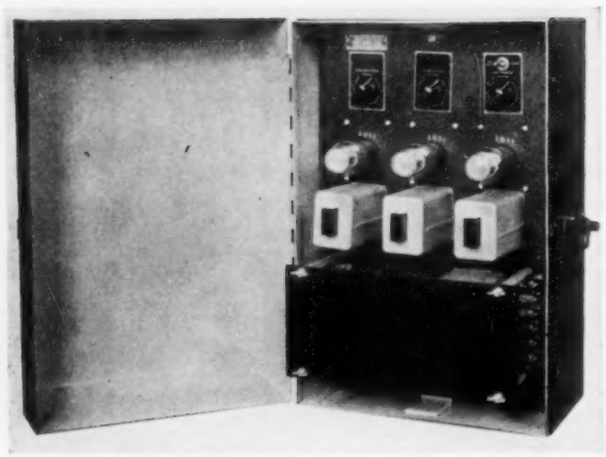


Fig. 2—Non-Synchronous Tube Timer

switching involved in pulsation welding, these problems will be discussed in detail.

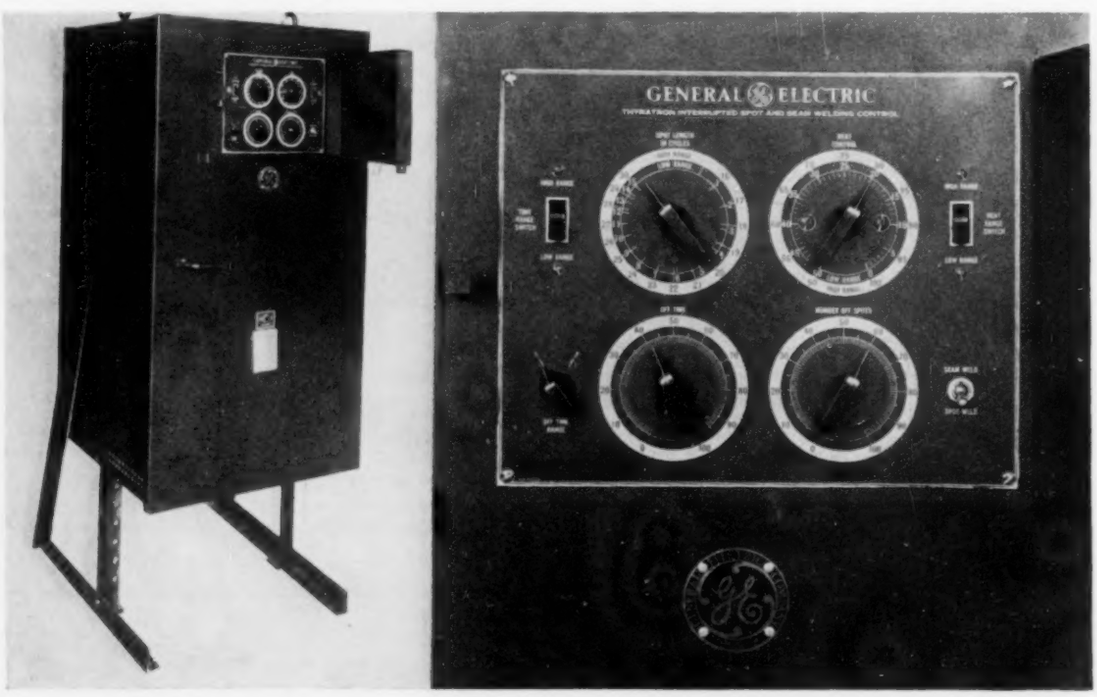
Transients, or surges, are caused by connecting transformer loads at other than that point on the voltage wave corresponding to zero current with steady state current conditions (the minimum transient point).

Oscillograms, Fig. 1, show the result of switching on the zero of the voltage wave and the value of respecting the power factor angle. If the circuit is closed at other than at the minimum transient point on the voltage wave (the power factor angle), a condition results wherein the first cycle of power may draw several times normal current resulting in excessive heating of the electrodes and a splash from the weld. If the transformer core saturates, the transformer heating becomes a still higher percentage. Fortunately, this condition gradually dies out over a few cycles. On the other hand, if the total time of current flow is for only a few cycles, transients may lead to a great percentage of variation. A synchronously operated mechanical switch might reduce the variation, but if contacting uniformly early or late would continue to cause an unnecessary line disturbance and perhaps extra transformer heating. Any variation in the starting point with relation to the voltage wave will cause a different amount of heat for each weld.

A direct-current component results when the transformer is switched onto the line with current flow starting with the same polarity as the last half-cycle of power when it was switched off. This condition results in an unduly large initial current demand, tending to saturate the transformer, especially if repeated rapidly, yet with a reduction of the welding current. Such a condition is frequently caused by non-synchronous switching, and may be caused by synchronous switching if improperly done.

With the synchronous electronic control transient currents are eliminated by the use of a peaking transformer circuit which accurately starts passing current to the welder at the same point on the voltage wave for each weld, i.e., at the minimum transient point. Direct-current components and the cumulative flux and consequent transformer saturation are eliminated by the so-called trailing tube circuit, i.e., current flow always starts with the same polarity and ends with the opposite polarity. Therefore, synchronous electronic controls, adjustable in one-cycle steps (instead of half-cycle steps) are to be preferred.

Synchronous controls, as explained previously, should always be used because they improve electrode life, produce more consistent results, demand lower current from the supply line and cause less heating of the welder transformer. Various types of synchronous electronic controls may be used. The fully electronic control panel built especially for pulsation welding, Fig. 3, includes a counting tube and adjusting dial to permit the operator to pre-set the number of pulsations. The dials are shown with greater details in Fig. 4. The number of cycles on, and the number of cyles off may each be varied independently from one (1) to thirty (30) cycles, and any



Figs. 3 and 4—Views of Thyratron Interrupted Spot- and Seam-Welding Control Panel

number of pulsations may be selected, usually from one (1) to fifteen (15). An additional dial is shown here for the adjustment of the welding heat by the phase-shift method. This provides the ultimate in the way of convenience, and cuts set-up time and delays to the minimum. This same control can also be used for conventional spot welding by adjusting the number of spots for one. By changing the position of one switch, this control can also be used for seam welding, in that the counting tube is cut out and the panel repeats continuously.

On the other hand, many seam welder controls stop and start the seam in response to the operation of a small switch which might be cam operated. If such a control were applied to a spot welder the number of pulsations would vary with the speed of the machine, other adjustments remaining the same. It is the adjustment of this number of pulsations that is clumsy and awkward with this cam arrangement.

Also, an ordinary spot welder control, Fig. 5, may be used with a multi-point cam to operate the initiating switch for each individual impulse of power. This control may be adjustable from 1 to 30 cycles of the 60-cycle power supply, and will pass current for only one impulse for each time that the initiating switch is closed. Although the cam-operated limit switch is not synchronous in operation, the synchronous control will always start passing current at the desired minimum transient point on the current wave, will always start at the same polarity and end with the opposite polarity. Therefore, there are no transient currents and neither is there any direct current component. With this arrangement the "off" time between impulses of power varies with the speed of the machine and it is difficult to obtain rapid operation. While this arrangement may be satisfactory on a large production job, a new set-up is expensive. Such equipment lacks the flexibility of adjustment necessary on the usual welder.

In place of the cam-operated switch to initiate the panel, simple electron tube timers are available, such as shown in Fig. 2. When used with a synchronous spot welder control, this timer will have only two dials; the combination, however, of the two panels together will provide time adjustment for the current-flow interval on the spot welder control, while the "off" timing will be provided by this auxiliary panel, and also the over-all interval during which the current will be intermittently applied to the welding machine will be provided by the second dial on the auxiliary control. This combination is suitable for a minimum of 3 cycles "on" and 3 cycles "off," but is adjustable up to 30 cycles "on" and 30 cycles "off" maximum ("on" and "off" time independently adjustable).

Some work has been done which shows that it is advantageous on some types of work to vary the lengths of successive periods of current flow. For instance, with heavy parts and good surface contact conditions, it might save time to use a much longer first period of current flow to quickly warm the parts. On the other hand, with some sensitive jobs it becomes desirable to use a shorter initial impulse of current. Figure 6 shows a General Electric pulsation welding control attachment with independent adjustments of the first, second and third periods of current flow, as applied to a standard Thyratron spot-welding control.

It is also desirable, in some cases, to use a heat-treating impulse of power at the end. This may be accomplished by using a fairly long off period after the weld is completed, followed by an impulse of power sufficiently long to effect this heat treatment.

Fig. 5—Thyratron Spot-Welding Control Panel

Fig. 6—Thyratron Interrupted-Spot-Welding Control Attachment with Independent Control of 1st, 2d and 3d Spot Lengths, Applied to Thyratron Spot-Welding Control

WATER COOLING

Pulsation welding seems to derive its value from two distinct effects, besides other advantages which will be discussed later. Intermittent current applications might be used with almost any sort of equipment with possible value in that a higher voltage and current used for shorter periods of application tend to break down surface defects and force the current to go where it should, when a small current would be more completely shunted.

The other effect is the original one discovered, which made it possible to weld heavier material in a given machine. The theory is that by interrupting the flow of current, water-cooled electrodes will get a new lease on life and keep the outer surfaces of the work cooler without appreciably lowering the temperature at the center of the mass being welded. In this way, heavy pieces may be spot welded in quantity production, which would ruin the electrodes with only a few welds if attempted by the conventional spot-welding method. All electrodes should be water cooled. The electrical resistance of electrode materials increases with temperature, and annealing is a matter of temperature and time, rather than of only temperature.

PRESSURE DWELL

The usual motor-driven spot and projection welders have definite limitations of the time of pressure dwell on the electrodes or work. Most of the larger machines can be slowed down sufficiently to accommodate a great variety of pulsation welding jobs. However, to go to the extreme, there are jobs on record that have required the maintenance of pressure for more than a minute. If one has a cam-operated machine driven by a slow D.C. motor, the outfit may be stopped with the pressure on for as long as desired. While this will do for a few welds, it is not a production tool. The more common arrangement today with both cam and toggle-operated equipment is to back-gear the drive shaft so that the clutch

makes two revolutions per weld cycle. Such a machine can operate as a conventional spot welder or by the simple flip of a switch or other device, the clutch will disengage with the head down and hold the pressure until the clutch is re-engaged to lift the head.

The double clutching cycle of operation not only gives any desired time of pressure dwell, but if a safety switch is provided to prevent current flow the assembly dimensions may be checked after pressure is applied but before welding. At other times it is a matter of checking to make sure that certain parts clear the electrodes before the current flow is initiated by hand. If it is desired to remove the human element from the double clutching operation and cut time delays to a minimum and definite figure, relays can be added to re-engage an electrically operated clutch automatically following a certain time delay after the welding current has ceased flowing.

EQUIPMENT FOR PULSATION WELDING

From the above it is self-evident that while motor-operated equipment will be used extensively for the application of pulsation spot and projection welding, the air or hydraulically operated equipment with its longer regulated pressure dwell time is ideally suited for this work. Full automatic sequence control is available for making these machines as fully automatic in operation as motor-driven equipment.

It may be stated that the most satisfactory equipment for the lighter range of pulsation spot and projection welding consists of the modern welding press, motor operated and back-geared to give double-clutch operation when wanted, or the air-operated welding press with automatic sequence control. For the heavier sections, the hydraulically operated heavy-duty welding press with automatic sequence control is the most desirable equipment.

For pulsation butt welding, invariably the sections will be in the heavier ranges and here again hydraulically operated equipment is desirable, with the same automatic sequence control as is used for the heavy-duty press welder.

For pulsation seam welding, the modern heavy-duty seam welder is used with an intermittent roll drive and the interrupting electronic control provided, when necessary, with an auxiliary pulsation control panel.

It must be understood that for consistently satisfactory results a thoroughly water-cooled secondary circuit and electrodes are required, as well as a synchronous electronic current interrupter or control, having dial adjustments for all variables. For repeated satisfactory results on quantity production work in the factory, automatic equipment is necessary.

The equipment outlined is all available as standard items today and its flexibility, or range of usefulness, is so much greater, its convenience and ease of set-up so time-saving and the product so much more uniform and dependable that the installation of modern welding equipment is unconditionally justified.

Another article in this series will be devoted largely to applications and advantages of pulsation welding with data for its use.

THE FABRICATION OF Large Equipment by Welding*

By LESLIE S. McPHEE†

BEFORE starting the actual welded fabrication of a product, consideration should be given to several items which will tend to make the fabrication process a success or a failure.

ENGINEERING DESIGN

Of prime importance is "Engineering Design." If welding, eventually, is to reach its deserved level, something must be done to acquaint all designers and engineers with the potentialities of this "Science of Welding," and to make them fully cognizant of those potentialities and requirements. Here the psychological angle presents a considerable problem in that the direction of flow of information must be reversed, that is, the engineer must obtain from somewhere the information that the shop man has already obtained through experience and research.

Few engineers in authoritative positions today have had time to keep abreast with the rapid progress of welding, the development of electrodes and welding machines, and the experiences of those of us who are in direct contact with those items. It is not difficult, then, to understand their wariness of accepting our enthusiasm unquestioningly.

We must realize that their design schooling was entirely in castings, forgings, plates and rivets; that practically all their designs and calculations were in these media; that a well-designed weldment appears to them to be too radical and extreme; and that they are not positive in their own minds as to the feasibility of this new method which has grown so rapidly in ten years' time. Perhaps we are expecting too much when we ask these men to disregard their theory of design and to acclaim a new process, when we know that they have spent the better part of their lives learning to use castings and rivets and, through the school of experience, are assured of the results they will obtain. Considerable time spent in study of welding is required and the natural lethargy against that is difficult to overcome. Not so many years ago welds were of inferior quality, so existent doubts are not without reason, even though we know that materials and equipment then were as much responsible as was the operator. Today, however, with the steel manufacturers and their metallurgists cognizant of the requisites of weldable materials plus the outstanding achievements of the rod and equipment manufacturers, welding has arrived.

Let's not pretend that all there is to know about welding has been learned, as there are remaining innumerable problems to be solved but many of these can be solved by the designer. It may take another genera-

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tion or two, or until the youngsters who are now in school are in the guiding positions in our industries, before we can expect welding to be used to its fullest advantage.

As we scrutinize the detail drawings of many of our industries there is no doubt left in our minds that the operator and practical welder have advanced beyond the designer with regard to their share of the problem. Too often the design is made with a riveted structure in mind, then the rivet size and spacing is omitted, a note is added "weld throughout," and that is called a welded design. When this is called to the attention of the draftsman, the answer is usually, "Well, the welding supervisor knows more about the strength of his welds than I do," which is probably true, but this is a deplorable condition. Although the welding supervisor usually does know the strength of the welds, he should not be expected to know the magnitude of the stresses developed or the theory of their application. Therefore, it is imperative that all information relative to welding be on the drawing, even to the smallest detail.

We will all agree that a structure can never be too high in quality except from an economic view-point, and from that reach the conclusion that the two main factors in a quality welded structure, whether large or small, are design, which has just been discussed, and material.

MATERIAL

The material manufacturers are doing a fair job when we consider the conditions under which they are working, but they are human and will evade any possible immediate responsibilities if without danger to their own prestige. They will do better, however, if they are pressed hard enough. The constituents of, and their proportions in, plates and shapes to be welded are almost entirely the responsibility of the steel producer. I say "almost" because it is not beyond the possibility of the designer to specify improper material. In most cases, however, the trouble is sooner or later traced back to the mill, but this does not enhance or save the reputation of welding or of the persons concerned.

Even in the consideration of welding wire, there have been cases where the mill has labeled and sold as seconds, batches of wire in which the carbon, silicon, phosphorus or sulphur have been a few points off specifications. A reputable manufacturer would not take a chance with an article of this sort. It is regretted that some people are more interested in quantity than in quality, and quality is one word that must be kept in mind as there is no other to replace it. For QUALITY, where welding is concerned, the best is not too good, whether it be base material, welding rod, welding machine or operator. The cost of the weld or of the material going into it should be of secondary importance. Quality does not mean that all welds should be of fired pressure vessel standards, because by economic necessity more than one class of welding is required, and poor welds in all classes can generally be traced to poor materials, design and equipment, quite as often as to poor workmanship.

Besides criticizing the producer of the base material, is it possible in some cases to criticize the purchaser or purchasing agent because of price chiseling tactics? While such tactics might constitute, at first glance, a healthy condition as far as a business proposition is concerned, just how much would a few extra cents per pound of welding rod affect the price of an entire job, and how much more quality could the manufacturer put in his rod for a few more cents per pound. I am not selling welding rods, but merely trying to point out the folly of trying to save pennies at the risk of reputation loss, and there is nothing which will jeopardize customer satisfaction more than faulty welding.

EQUIPMENT

Now that we have considered design and material, our next thought is the equipment necessary for the preparation of the material for welding. Today, one of the most important, if not the most important, pieces of equipment is the flame-cutting machine. Here we find a tool with flexibility of application, and capacity practically unlimited. Whether the material is one-sixteenth of an inch thick, or six inches thick, flame preparation is applicable.

If the material to be fabricated is other than the standard run of structural steel such as nickel, copper or stainless, of course a shear and plate planer are necessary.

Next in the order of importance is a modern press-break. While this is a comparatively expensive piece of equipment, it is imperative to the economy of weld design. By its proper use, the designer is enabled to eliminate a large number of corner welds, thereby reducing the cost and at the same time improving the appearance of the finished product. Forming and bending which were practically impossible with the old style bend-break are an every-day occurrence in a portion of the time with this machine, not to mention the superior results obtained.

The plate and bar rolls are presumed to be a part of every structural fabricating plant, the main requisite being that there be two sets: one large enough for the maximum demand and one small enough for the minimum. While a furnace for heating material too heavy for cold forming is advantageous, it is not an absolute economic necessity in view of the production methods and cost reductions accomplished by the mills. While a preheating or postheating oven is desirable for the welding of the higher carbon steels (above 30–40) carbon and necessary for the stress relief of heavy pressure vessel code work, it is not necessary for the general run of welding if the filler metal used is of high ductility.

PREPARATION OF MATERIAL

Preparation of the material to be welded is of as great importance from a physical as well as an economic standpoint as the welding itself. Where this operation is accomplished in a separate structural department which is usually the case in the older plants where welding has developed from a maintenance tool to a major production department proper preparation is doubtlessly a bone of contention, probably due to the fact that the persons preparing the material have never had the opportunity of welding a joint, much less one that was poorly prepared; they, therefore, cannot be expected to share the view-point of the welder nor appreciate the justification of his complaints. However, after an investigation of welded fabrication, we find that the preparation of the material rates next to design in the consideration of economy, distortion or locked-up stresses and, last but not least, the morale of the welding operator.

When preparing the joints in materials under $^3/_4$ inch thick, it is doubtlessly more economical to use the plate planer for this purpose as a closer control can be held over the contour and tolerance of the bevel or groove. However, on materials over $^3/_4$ inch thick, economy practically forces the use of the bevelling or scarfing torch for this operation.

Having given due consideration to the preparation of the material, the next item in sequence and importance is set-up assembly and tack welding. We find for this

operation that personnel again plays a major part and that the most satisfactory person for this operation is not merely a structural assemblyman but an experienced welder with the ability to read drawings. This is true because of the fact that a welder is fully cognizant of what a poor fit will mean to the final cost. He also has a working knowledge of distortion and can generally predict which way and about how much the parts will shrink. He realizes the disadvantages of tacks that are too large and just how small they can be and still be expected to hold. After the parts have been assembled and tacked, the next thought is to get them into the most economical as well as the most convenient position for welding, which is naturally the flat or downhand position and which necessitates positioning equipment, manipulators, tank rolls, cranes, hoists, adjustable scaffolding, etc. This equipment pays the highest form of dividends relative to cost reduction, stress distribution, appearance and a partial elimination of the human element. Jigs and fixtures for parts that are to be duplicated by welding are no place to try to save money. A few dollars more spent on a jig or fixture is a sure-fire means of increasing the profit rate from that equipment. For a quality product, your men—though exceptional they may be—must have quality materials and equipment to start with.

Though we have above the average headroom under our traveling cranes, we have found a decided advantage in a pit at one end of our shop the full width of the building and twenty feet deep which enables us to assemble large bodies in a vertical position, thus eliminating a great deal of hard labor and jockeying of parts to get them in position for tacking, at the same time affording us an opportunity of working on all sides of the vessel at the same time in perfect safety.

PERSONNEL

Now, having considered all the preliminaries, we approach the welding personnel and even though we have attained a Utopia up to this point, we must realize that real welders are not out of work very long. Your personnel department may tell you that they have any number of welders' applications for work, but when you begin to check these applicants with practical tests, you realize they are welders merely in their own estimation. We have found, after culling out the applications that appeared to be doubtful, that if we hired one potential welder out of ten we were doing satisfactorily. Perhaps we have set our standard too high but, again, that is an impossibility where welding is concerned. Any number of welders can be hired that are able to satisfactorily perform one or two specific welding operations, but let's not term these men welders, for undoubtedly they lack experience and if you anticipate training welders, it is best to have them without someone else's conception of what a weld should be.

In our own organization the majority of our key men have been with us continuously for the past ten years and naturally do not demand the amount of supervision that would be necessary with short-term operators inconsiderate of their proficiency. Each welder is furnished with an individual signature stamp which must be on every weld he makes and the inspection department has instructions to reject any fabrication which does not have the signature stamp on every weld. This places the responsibility of every weld upon the person who produced it and reduces the possibility of a welder doing an inferior job.

The size and type of welding rod is left to the discretion of the supervisor which is ideal from a practical viewpoint because of the variation in thicknesses of material to be penetrated, shapes of grooves and facilities for positioning. In a production shop, this would not hold true and the type and size of rod could be predetermined and specified on the drawings, thereby eliminating one more phase of the human element.

Having looked at the different necessities for fabrication, one might wonder how they are accomplished and coordinated, so let's follow a job from the engineering department to the freight car. When the drawings and bills of material are completed in the engineering department, the first operation is to source the material. This is done by the stores department which takes the original bill of material before duplication and marks each item, showing whether it is carried in stock or is to be purchased. When this operation is completed, the bills are duplicated and a copy of each page delivered to the department concerned.

Upon receipt of their bills and drawings, the purchasing department immediately orders all materials so designated and follows their production until delivery into our plant, and as soon as the vendor furnishes a delivery date for the ordered material, the production department schedules the shipping date to the routing department.

The routing department is composed of persons having complete knowledge of each operation performed in every manufacturing department in the plant, and it is their duty to study the drawings and break each unit down into its component parts and route them for their many operations, giving the date of completion in each department.

A requisition for the material is attached to the route card and delivered to the department performing the first operation. Here the material is drawn from stock and marked with the job number, drawing number and part number. As this operation is completed, the material is moved to the next department specified on the route card.

The route card is then turned in to the operations office where the completion of the operation is noted on a duplicate route card and then delivered to the next department for fabrication.

In the case of a neck for a tank, the first operation would be layout in the structural department. They would turn the requisitions into the stores, receive the plate, lay out for shearing and send it to the shears where the second operation would be performed. The third operation would be rolling and delivering to the weld shop. The fourth operation would be to flame-cut the flange. The fifth operation to weld flange and neck and deliver to the lathe. Sixth operation would be to face and deliver to the layout department for bolt holes. Seventh, lay out bolt holes. The eighth operation would be to drill and deliver to weld department, and ninth to assemble and weld in place and the route card returned to the operations office showing completion.

After each operation, the route card is turned in to the operations office for designating on the duplicate route card the status of completion and location of the part, thereby enabling the production department to obtain the exact status of the job at any time.

In view of the fact that a part of our jobs are large enough to necessitate ten or twelve cars for shipment and two to three weeks for erection, the control of the sequence of completion of each different unit is entirely necessary to facilitate erection in the field and the elimination of demurrage charges.

While conditions in other organizations are undoubtedly as varied as they are numerous, we find in our own plant that, by continued perseverance and cooperation, a constant improvement is being accomplished in weld design, preparation and quality of the finished product.

Stress Control Without Preheating

Preheating of Cast-Iron Pulleys and Gears Is Unnecessary with These Welding Procedures

By F. F. MOONEY*

IN THE repair of fractured cast-iron pulleys or gears, the operator must control expansion and contraction stresses in the part during welding and immediately afterward while the part is cooling. This is usually accomplished successfully by careful preheating, postheating and control cooling. However, emergencies may arise when such practices might be impossible because of a lack of preheating facilities, or undesirable because the size of the part makes preheating uneconomical. The procedures described here have been used successfully by contract shops for the bronze-welding and fusion welding of fractures in cast-iron pulleys and gears without preheating.

ONE SPOKE FRACTURED

When a single spoke is fractured near the solid hub of a pulley, the procedure for controlling stresses is relatively simple. The fracture is first veed from both sides, preferably by chipping. Then a hack saw cut is made in the same spoke at a point close to the rim. This cut, however, is not made completely through the spoke, but preferably is made from both broad sides of the spoke in such a manner as to leave a strip of uncut metal about $1/4$ inch thick across the center section. The welding of the original fracture can then be carried on without special preheating. The additional opening, provided by the hack saw cut, will permit expansion of the spoke while the fracture is being welded. The uncut section will keep the spoke in line.

After the welded fracture has cooled to room temperature, the hack saw cut is welded closed. In order to obtain complete penetration this portion of the spoke is first carefully veed by chipping. Because of the location of this weld, sufficient heat from the blowpipe flame will be carried over into the adjacent rim so that expansion will be taken care of by flexing of the rim.

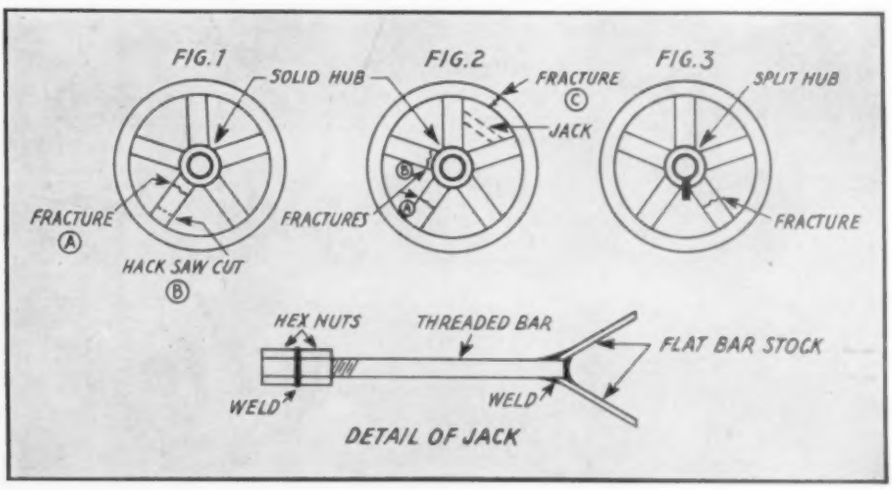
* The Linde Air Products Company.

MULTIPLE FRACTURES

When a combination of rim and spoke fractures exists, as shown in Fig. 2, the order of welding is important. After the fractures have been veed, spoke welds *A* and *B* are completed in that order. Weld *B*, however, should not be attempted until weld *A* has completely cooled. When weld *B* has cooled to room temperature, a jack, such as is shown in the sketch, is employed before proceeding with weld *C*. The jack, placed between the spokes on either side of the rim fracture, is adjusted so as to force the fracture open approximately $1/16$ inch. The clearance thus provided is sufficient to permit normal expansion of the rim during welding. After this final weld has been completed, the jack is removed and the weld is allowed to cool. It will be found that the resultant contraction will not cause a recurrence of the breakage.

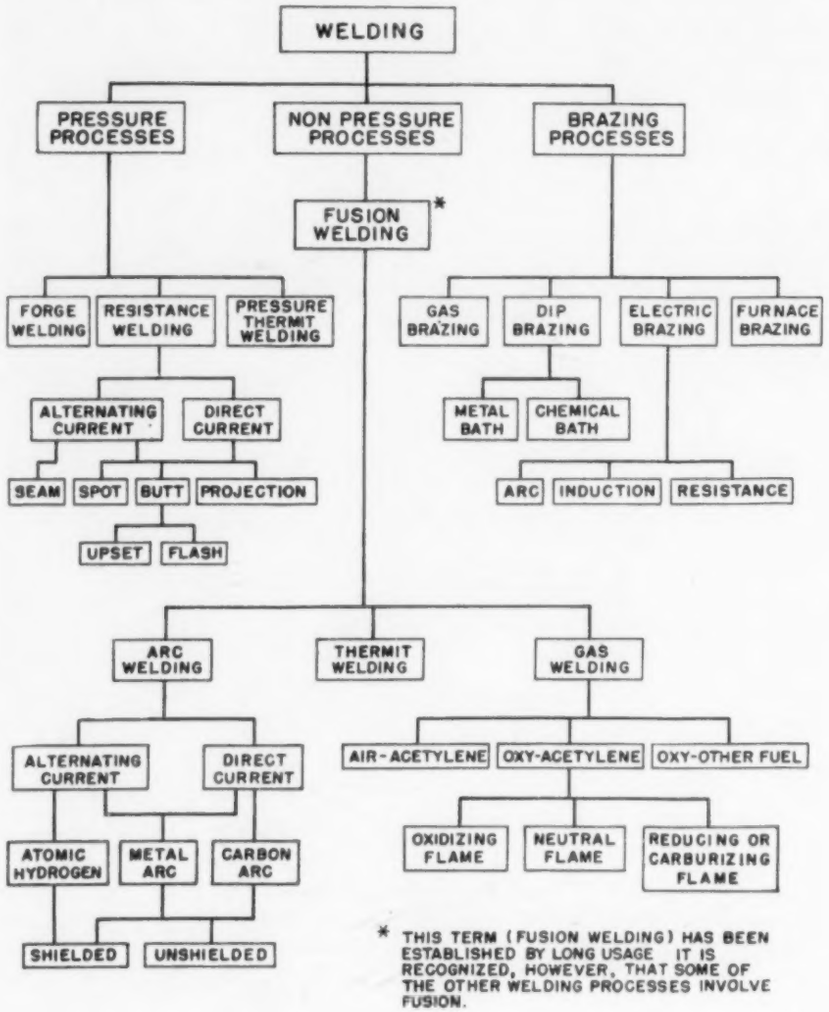
SPLIT-HUB PULLEYS

With gears or pulleys of the split-hub type, a spoke broken adjacent to the hub can be repaired readily without preheating. In this case the fracture is prepared for welding by veeing in the usual manner. Then a shaft, or section of shaft, about $1/16$ inch smaller in diameter than the bore of the hub, is inserted through the hub. Bolts are then applied and tightened until the split hub fits tightly around the shaft. As a result of this the portion of the broken spoke adjacent to the hub will be drawn away from the balance of the spoke and the fracture will be opened sufficiently to take care of expansion caused by the heat of welding. After the welding operation has been completed, pressure, previously applied to the split hub, is released by removing the hub bolts. This completes the repair and the part is allowed to cool, without danger of breakage due to subsequent contraction stresses.



Proper Procedure Often Can Eliminate Preheating in Welding Cast-Iron Gears and Pulleys. Letters Indicate Order in Which Welds Should Be Made

MASTER CHART OF WELDING PROCESSES



* THIS TERM (FUSION WELDING) HAS BEEN ESTABLISHED BY LONG USAGE IT IS RECOGNIZED, HOWEVER, THAT SOME OF THE OTHER WELDING PROCESSES INVOLVE FUSION.

Definitions of Welding Terms*

Actual Throat: See Throat of Fillet Weld. See Figure 40.

Air-Acetylene Welding: A gas welding process wherein the welding heat is obtained from the combustion of air and acetylene.

All Weld Metal Test Specimen: A test specimen wherein the portion being tested is composed wholly of weld metal.

Alternating Current Arc Welding: An arc welding process wherein the power supply at the arc is alternating current.

Arc Brazing: An electric brazing process wherein the heat is obtained from an electric arc, formed between the base metal and an electrode, or between two electrodes.

Arc Voltage: The voltage across the arc.

Arc Welding: A non-pressure (fusion) welding process wherein the welding heat is obtained from an arc either between the base metal and an electrode, or between two electrodes.

Atomic Hydrogen Welding: An alternating current arc welding process wherein the welding heat is obtained from an arc between two suitable electrodes in an atmosphere of hydrogen.

Automatic Welding: Welding with equipment which automatically controls the entire welding operation. (Including feed, speed, oscillation, interruption, etc.)

Axis of a Weld: A line through the weld parallel to the root. See Figure 1.

Backfire: The momentary recession of the flame into the torch tip followed by immediate reappearance or complete extinguishment.

Backhand Welding: A gas welding technique wherein the flame is directed opposite to the progress of welding.

Back-Step Welding: A welding technique wherein the increments of weld metal are deposited opposite to the direction of progression.

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*NOTE:

1. In some definitions alternative terms are shown in parentheses. In each instance the first term is preferred.
2. For definitions of electrical terms see definitions prepared by National Electrical Manufacturers Association.
3. Prepared by the Committee on Definitions and Chart and approved by Executive Committee as "Tentative," Jan. 18, 1940.

Backing Strip: Material (metal, asbestos, carbon, etc.) backing up the

Composite Electrode: An electrode with or without a flux having more than one filler material combined mechanically.

Backing Strip: Material (metal, asbestos, carbon, etc.) backing up the root of the weld.

Bare (Lightly Coated) Electrode: A solid metal electrode with no coating other than that incidental to the manufacture of the electrode, or with a light coating.

Base Metal (Parent Metal): The metal to be welded, or cut.

Base Metal Test Specimen: A test specimen composed wholly of base metal.

Bead Weld: A type of weld made by one passage of electrode or rod. See Figure 17.

Beading (Parallel Beads): A technique of depositing weld metal without oscillation of the electrode. See Figure 46.

Bend Test: See Free Bend Test and Guided Bend Test.

Bevel Angle: See Groove Angle, Figure 32.

Bevel Weld: See Groove Weld.

Bond: The junction of the weld metal and the base metal.

Brazing: A group of welding processes wherein the filler metal is a non-ferrous metal or alloy whose melting point is higher than 1000° F. but is lower than that of the metals or alloys to be joined.

Build-Up Sequence: The method of depositing a multiple pass weld with respect to its cross section.

Butt Joint: See Figure 2.

Butt Resistance Weld: See Figure 25.

Butt Resistance Welding: See Resistance Butt Welding.

Carbon Arc Cutting: The process of severing metals by melting with the heat of the carbon arc.

Carbon Arc Welding: An arc welding process wherein a carbon or graphite electrode or electrodes is used, with or without the use of filler metal.

Carbon Electrode: See Electrode.

Carburizing (Carbonizing) Flame: A gas flame having the property of introducing carbon into the metal heated.

Cast Iron Thermit: A thermit mixture containing additions of ferro-silicon and mild steel.

Chain Intermittent Fillet Welds: See Figure 20

Chemical Dip Brazing: A dip brazing process wherein the filler metal is added to the joint before immersion in a bath of molten chemicals.

Coated Electrode: See Covered Electrodes.

Collar: The reinforcing metal of a non-pressure thermit weld.

Composite Electrode: An electrode with or without a flux having more than one filler material combined mechanically.

Composite Joint: A joint wherein welding is used in conjunction with a mechanical joint.

Concave Fillet Weld: See Figure 41.

Concurrent Heating: Supplementary heat applied to a structure during the course of welding.

Cone: The conical part of a gas flame which is next to the orifice of the tip.

Contact Jaw: An electrical terminal used in a resistance butt-welding machine to securely clamp the parts to be welded and conduct the electric current to these parts.

Continuous Weld: A weld which extends continuously for its entire length.

Convex Fillet Weld: See Figure 41.

Convexity Ratio: See Figure 47.

Corner Joint: See Figure 3.

Covered (Shielded Arc) Electrode: A metal electrode which has a relatively thick covering material serving the dual purpose of stabilizing the arc and improving the properties of the weld metal.

Cover Glass: A clear glass used to protect the lens in goggles, face shields and helmets from spattering material.

Crater: A depression at the termination of an arc weld.

Cutting Process: Chemical reaction type—See Gas Cutting. Melting type—See Carbon Arc and Metal Arc Cutting.

Cutting Tip (Nozzle): A gas torch tip especially adapted for cutting.

Cutting Torch or Blowpipe: A device used in gas cutting for controlling the gases used for preheating and the oxygen for severing the metal.

Cylinder (Bottle): A portable container used for storage of a compressed gas.

Deposited Metal: Metal that has been added by a welding process.

Deposition Efficiency: The ratio of the weight of deposited metal to the net weight of the electrodes consumed (exclusive of stubs).

Depth of Fusion: See Penetration. See Figure 42.

Dip Brazing: A group of brazing processes wherein the heat is obtained from a bath of molten metal or chemical; the filler metal may or may not be obtained from the bath.

Direct Current Arc Welding: An arc-welding process wherein the power supply at the arc is direct current.

Double Groove Welds: See Groove Welds.

Edge Joint: See Figure 4.

Edge Preparation: See Figure 26.

Effective Length of Weld: The length of the correctly proportioned cross section of a weld.

Electric Brazing: A group of brazing processes wherein the heat is obtained from electric current.

Electrode:

A. *Metal Arc Welding:* Filler metal in the form of a wire or rod, either bare or covered, through which current is conducted between the electrode holder and the arc.

B. *Carbon Arc:* A carbon or graphite rod through which current is conducted between the electrode holder and the arc.

C. *Atomic Hydrogen:* One of two tungsten rods between the points of which the arc is maintained.

D. *Resistance Welding:* A bar, wheel or die through which the current is conducted and the pressure applied to the work.

Electrode Holder: A device used for mechanically holding the electrode.

Electrode Tip (Point): A replaceable tip of metal on an electrode having the electrical and physical characteristics required for spot and projection welding.

Face of Weld: See Figure 35.

Filler Metal: Material to be added in making a weld.

Fillet Weld: See Figure 16.

Fillet Weld Size: See Size.

Filter Lens: A colored glass used in goggles, helmets and shields to exclude harmful light rays.

Flashback: A recession of the flame into or back of the mixing chamber of the torch.

Flash Butt Welding: A resistance butt welding process wherein the potential is applied before the parts are brought in contact and where the heat is derived principally from a series of arcs between the parts being welded.

Flash (Fin): Metal expelled from a joint made by the resistance welding process.

Flat Position of Welding (Downhand): See Figure 1.

Flush Weld: A weld made with a minimum reinforcement.

Flux: A fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides or other undesirable inclusions formed in welding.

Forehand Welding: A gas welding technique wherein the flame is directed toward the progress of welding.

Forge Welding (Blacksmith, Roll, Hammer): A group of pressure welding processes wherein the parts to be welded are brought to suitable temperature by means of external heating and the weld is consumated by pressure or blows.

Forging Thermit: A thermit mixture with the addition of carbon, manganese, nickel and mild steel.

Free Bend Test Specimen: A specimen which is tested by bending without constraint of a jig.

Full Fillet Weld: A fillet weld whose size is equal to the thickness of the thinner member joined.

Furnace Brazing: A brazing process wherein the heat is obtained from a furnace.

Fusion Welding (See Chart): A group of processes in which metals are welded together by bringing them to the molten state at the surfaces to be joined, with or without the addition of filler metal, without the application of mechanical pressure or blows.

Gas Brazing: A brazing process wherein the heat is obtained from a gas flame.

Gas Cutting: The process of severing ferrous metals by means of the chemical action of oxygen on elements in the base metal.

Gas Pocket (Blow-Hole): A cavity in a weld caused by gas inclusion.

Gas Welding: A non-pressure (fusion) welding process wherein the welding heat is obtained from a gas flame.

Groove (Scarf): See Figure 27.

Groove Angle: See Figure 32.

Groove Welds:

(*a*)	Square Groove Weld:	See Figure	7
(*b*)	Single-Vee Groove Weld:	" "	8
(*c*)	Single Bevel Groove Weld:	" "	9
(*d*)	Single-U Groove Weld:	" "	10
(*e*)	Single-J Groove Weld:	" "	11
(*f*)	Double-Vee Groove Weld:	" "	12
(*g*)	Double Bevel Groove Weld:	" "	13
(*h*)	Double-U Groove Weld:	" "	14
(*i*)	Double-J Groove Weld:	" "	15

Ground Connections: See Welding Ground.

Guided Bend Test: A bending test wherein the specimen is bent to a

Metal Arc Cutting: The process of severing metals by melting with the heat of the metal arc.

Flash Weld: A weld made with a minimum reinforcement.

Ground Connections: See Welding Ground.

Guided Bend Test: A bending test wherein the specimen is bent to a definite shape by means of a jig.

Hammer Welding: See Forge Welding.

Hand (Face) Shield: A protective device used in arc welding for shielding the face and neck, equipped with suitable filter glass lens and designed to be held by hand.

Heat-Affected Zone: The portion of the base metal whose structure or properties have been altered by the heat of welding or cutting.

Heating Gate: The opening in a thermit mould through which the parts to be welded are preheated.

Helmet Shield: A protective device used in arc welding for shielding the face and neck, equipped with suitable filter glass lens and designed to be worn on the head.

Horizontal Position of Welding: See Figure 1.

Included Angle: See Figure 33.

Induction Brazing: An electric brazing process wherein the heat is obtained from induced current.

Interrupted Spot Welding: A spot welding process wherein fusion is accomplished by means of successive applications of electrical energy between contact electrodes during a single application of pressure to the electrodes.

Intermittent Weld: A weld whose continuity is broken by unwelded spaces.

J Groove Welds: See Groove Welds.

Kerf: The space from which the metal has been removed by a cutting process.

Lap Joint: See Figure 5.

Layer: See Figure 44.

Leg of Fillet Weld: See Figure 39.

Lens: See Filter Lens.

Manifold: A multiple header for connection of individual gas cylinders or torch supply lines.

Manual Weld: A weld wherein the arc is controlled or the torch is manipulated by hand.

Melting Rate: The weight of electrode consumed in a unit of time.

Melting Ratio: The ratio of the volume of weld metal below the original surface of the base metal to the total volume of the weld metal.

Metal Arc Cutting: The process of severing metals by melting with the heat of the metal arc.

Metal Arc Welding: An arc welding process wherein the electrode supplies the filler metal in the weld.

Metal Dip Brazing: A dip brazing process wherein the filler metal is obtained from the molten metal bath.

Metal Electrode: See Electrode.

Mixing Chamber: That part of a gas welding or cutting torch wherein the gases are mixed for combustion.

Multiple Resistance Welding: A resistance welding process wherein two or more separate welds are made simultaneously.

Neutral Flame: A gas welding flame wherein the portion used is neither oxidizing nor reducing. See Figure 48.

Non-Pressure Welding: A group of welding processes wherein the weld is made without pressure.

Open Joints: See Root Opening. See Figure 31.

Overhead Position of Welding: See Figure 1.

Overlap (Roll): Protrusion of weld metal at the toe of a weld beyond the limits of fusion.

Oxidizing Flame: A gas welding flame wherein the portion used has an oxidizing effect. See Figure 49.

Oxy-Acetylene Welding: A gas welding process wherein the welding heat is obtained from the combustion of oxygen and acetylene.

Oxy-Other Fuel Gas Welding: A gas welding process wherein the welding heat is obtained from the combustion of oxygen and any fuel gas other than acetylene.

Pass: The weld metal deposited by one general progression along the axis of a weld. See Figure 43.

Pass Sequence: The method of depositing a weld with respect to its length.

Peening: Mechanical working of metal by means of hammer blows.

Penetration: The penetration, or depth of fusion, of a weld is the distance from the original surface of the base metal to that point at which fusion ceases. See Figure 42

Percussive Welding: A resistance welding process utilizing stored up electrical energy suddenly discharged.

Piping—Positions for Welding:

(*a*) *Horizontal Fixed Position:* When the axis of the piping is in a horizontal position (within the same limits as specified for axis of welds in Figure 1) and the piping is not rotated during welding. In this position welding is done in the flat, vertical and overhead positions, as defined in Figure 1.

(*b*) *Horizontal Rolled Position:* When the axis of the piping is in a horizontal position (within the same limits as specified for axis of welds in Figure 1) and the piping is rotated during welding. In this position welding is done in the flat position, as defined in Figure 1.

(*c*) *Vertical Position:* When the axis of the piping is in a vertical position (within the same limits as specified for axis of welds in Figure 1); the piping may or may not be rotated during welding. In this position welding is done in the horizontal position, as defined in Figure 1.

Plain Thermit: A mixture of iron oxide and finely divided aluminum.

Plug Weld: See Figure 18.

Poke Welding: A spot welding process wherein pressure is applied manually to one electrode only.

Porosity: The presence of gas pockets or inclusions.

Positions of Welds: See Figure 1 and Piping—Positions for Welding.

Postheating: Heat applied subsequent to welding or cutting operations.

Preheating: Heat applied prior to welding or cutting operations.

Pressure Thermit Welding: A pressure welding process wherein the heat is obtained from the liquid products of a thermit reaction.

Pressure Welding: A group of welding processes wherein the weld is consummated by pressure.

Progressive Spot Welding: A resistance spot welding process wherein two or more spot welds are made automatically one after the other by the actuation of a single control device.

Projection Weld: See Figure 23.

Projection Welding: A resistance welding process wherein localization of heat between two surfaces or between the end of one member and surface of another is effected by projections.

Rate of Deposition: The weight of weld metal deposited in a unit of time.

Rate of Flame Propagation: The speed at which a flame travels through a mixture of gases.

Reducing Flame: A gas welding flame wherein the portion used has a reducing effect. See Figure 50.

Reinforcement of Weld: See Figure 37.

Residual Stress: Stresses remaining in a structure or member as a result of thermal or mechanical treatment, or both.

Resistance Brazing: An electric brazing process wherein the heat is obtained from the resistance to the flow of an electric current.

Resistance Butt Weld: See Figure 25.

Resistance Butt Welding: A group of resistance welding processes wherein the fusion occurs simultaneously over the entire contact area of the parts being joined.

Resistance Flash Butt Welding: See Flash Butt Welding.

Resistance Welding: A pressure welding process wherein the heat is obtained from the resistance to the flow of an electric current.

Resistance Welding Time: Duration of the welding current.

Reversed Polarity (Electrode Positive): The arrangement of direct current arc welding leads wherein the work is the negative pole and the electrode is the positive pole in the arc circuit.

Root Edge: See Figure 28.

Root Face (Shoulder): See Figure 29.

Root Opening: See Figure 31.

Root of Weld: See Figure 34.

Root Radius: See Figure 30.

Seal Weld: A weld used primarily to obtain tightness.

Seam Weld: See Figure 24.

Seam Welding: A resistance welding process wherein overlapping or tangent spot welds are made progressively.

Semi-Automatic Metal Arc Weld: A weld made with equipment which automatically controls the feed of the electrode—the manipulation of the electrode being controlled by hand.

Series Welding: A resistance welding process wherein two or more welds are made simultaneously in a single welding circuit with the total current passing through every weld.

Shielded Carbon Arc Welding: A carbon arc welding process wherein the arc and molten weld metal are protected from the atmosphere by a shielding medium.

Shielded Metal Arc Welding: A metal arc welding process wherein the arc and weld metal are protected from the atmosphere by a shielding medium.

Silver Alloy Brazing (Silver Soldering): A brazing process wherein a silver alloy is used as a filler metal.

Single-Groove Welds: See Groove Welds.

Size:

(*a*) *Fillet Weld:* The size of a fillet weld is the leg length of the largest inscribed isosceles right triangle. See Figure 41.

(*b*) *Groove Weld:* The size of a groove weld is the depth of the groove. Where fusion materially exceeds the groove depth, the size of the weld is the depth of the groove plus the depth of fusion.

Slag Inclusion: Non-metallic material entrapped in a weld.

U Groove Welds: See Groove Welds.

Unaffected Zone: That portion of the base metal outside of the heat-

Slag Inclusion: Non-metallic material entrapped in a weld.

Slot Weld: See Figure 19.

Spatter Loss: The difference in weight between the weight of electrode deposited and the weight of the electrode consumed (melted).

Spot Weld: See Figure 22.

Spot Welding: A resistance welding process wherein the fusion is confined to a relatively small portion of the area of the lapped parts to be joined.

Square Groove Weld: See Groove Welds.

Staggered Intermittent Fillet Welds: See Figure 21.

Straight Polarity (Electrode Negative): The arrangement of direct current arc welding leads wherein the work is the positive pole and the electrode is the negative pole of the arc circuit.

Stress Relief Heat Treatment:* Uniform heating of a structure or portion thereof to a sufficient temperature below the critical range, to relieve the major portion of the residual stresses, followed by uniform cooling.

*NOTE: Terms normalizing, annealing, etc., are misnomers for this application.

Tack Weld: A weld used for assembly preparation purposes only.

Tee Joint: See Figure 6.

Theoretical Throat: See Throat of Fillet Weld. See Figure 40.

Thermal Stress: The stresses produced in a structure or member caused by differences in temperature or coefficients of expansion.

Thermit Crucible: The vessel in which the thermit reaction takes place.

Thermit Mixture: A mixture of plain thermit and other alloying metals.

Thermit Mould: A mould formed around the parts to be welded, to receive the molten metal.

Thermit Reaction: A chemical reaction between iron oxide and aluminum which produces a highly superheated liquid iron and aluminum oxide slag.

Thermit Welding: A non-pressure (fusion) welding process wherein the heat is obtained from liquid steel produced by a thermit reaction, and the filler metal is supplied by the steel produced in this reaction.

Throat of Fillet Weld: See Figure 40.

Toe of Weld: See Figure 36.

Types of Welds: See "Bead," "Fillet," "Plug," "Slot" and "Groove" Welds.

U Groove Welds: See Groove Welds.

Unaffected Zone: That portion of the base metal outside of the heat-affected zone wherein no change in physical properties or microstructure has taken place.

Undercut: See Figure 38.

Unshielded Carbon Arc Welding: A carbon arc welding process wherein no shielding medium is used.

Unshielded Metal Arc Welding: A metal arc welding process wherein no shielding medium is used.

Upset Butt Welding: A resistance butt welding process wherein the potential is applied after the parts to be welded are brought in contact and where the heat is derived principally from resistance.

Vertical Position of Welding: See Figure 1.

Wax Pattern: Wax moulded around the parts to be welded by the thermit welding process, to the form desired for the completed weld.

Weaving: A technique of depositing weld metal in which the electrode is oscillated. See Figure 45.

Weld: A localized consolidation of metals by a welding process.

Welded Joint: A localized union of two or more parts by welding.

Weldment: An assembly whose component parts are joined by welding.

Weld Metal: The metal resulting from the fusion of the filler or base metals or both.

Weld Penetration: See Figure 42.

Welding Ground: The side of the circuit opposite the welding electrode.

Welding Leads: Conductors furnishing an electrical path between source of welding power and electrodes.

Welding Operator: An operator of welding equipment.

Welding Pressure: External force applied in the pressure welding processes to control the current density throughout the weld, or effects of fusion, or both.

Welding Procedure: The detailed methods and practices involved in the production of a welded structure.

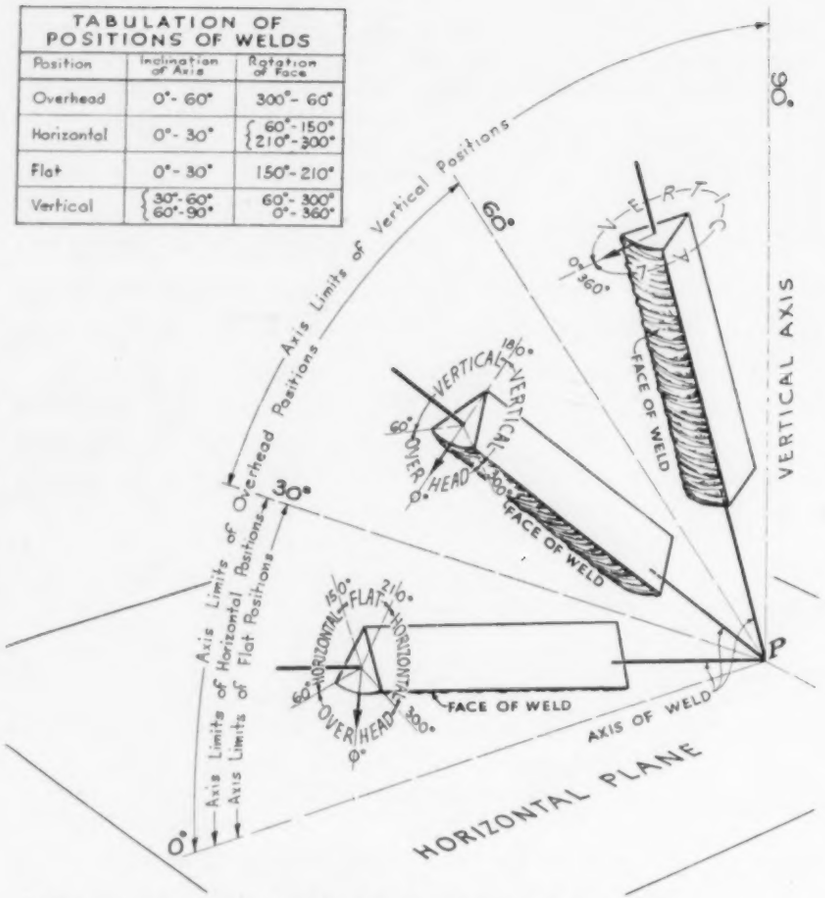
Welding Rod: Filler metal, in wire or rod form, used in the gas welding process and those arc welding processes wherein the electrode does not furnish the metal.

Welding Sequence: The order of welding the component parts of a structure.

Welding Tip: A gas torch tip especially adapted for welding.

Welding Torch or Blow Pipe: A device used in gas welding for mixing and controlling the gases.

TABULATION OF POSITIONS OF WELDS		
Position	Inclination of Axis	Rotation of Face
Overhead	0°- 60°	300°- 60°
Horizontal	0°- 30°	{60°- 150° {210°- 300°
Flat	0°- 30°	150°- 210°
Vertical	{30°- 60° {60°- 90°	60°- 300° 0°- 360°



The horizontal reference plane is taken to lie always below the weld under consideration.

Inclination of axis is measured from the horizontal reference plane toward the vertical.

Angle of rotation of face is measured from a line perpendicular to the axis of the weld and lying in a vertical plane containing this axis. The reference position (0°) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. The angle of rotation of the face of weld is measured in a clockwise direction from this reference position (0°) when looking toward point "P."

Fig. 1—Position of Welds

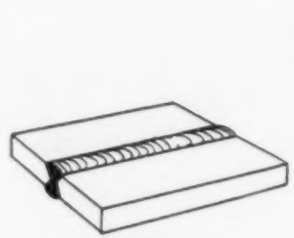


Fig. 2—Butt Joint

Types of Welds Applicable to Butt Joints
Square Groove
Single-V Groove
Double-V Groove (Illustrated)
Single Bevel Groove
Double Bevel Groove
Single-U Groove
Double-U Groove
Single-J Groove
Double-J Groove
Butt (Resistance)

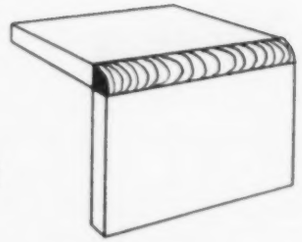


Fig. 3—Corner Joint

Types of Welds Applicable to Corner Joints
Fillet (Illustrated)
Square Groove
Single-V Groove
Single Bevel Groove
Double Bevel Groove
Single-U Groove
Single-J Groove
Double-J Groove
Projection (Resistance)

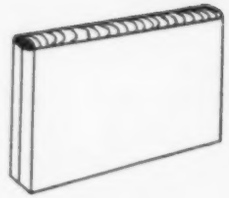


Fig. 4—Edge Joint

Types of Welds Applicable to Edge Joints
Bead (Illustrated)
Single-V Groove
Single-U Groove

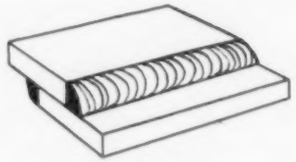


Fig. 5—Lap Joint

Type of Welds Applicable to Lap Joints
Fillet (Illustrated)
Plug
Slot
Spot (Resistance)
Seam (Resistance)
Projection (Resistance)

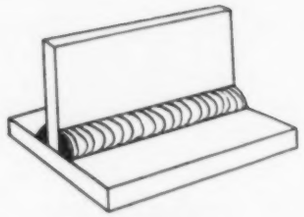


Fig. 6—Tee Joint

Types of Welds Applicable to Tee Joints
Fillet (Illustrated)
Single Bevel Groove
Double Bevel Groove
Single-J Groove
Double-J Groove

Fig. 7—Square Groove Weld

Fig. 8—Single-V Groove Weld

Fig. 9—Single Bevel Groove Weld

Fig. 10—Single-U Groove Weld

Fig. 11—Single-J Groove Weld

Fig. 12—Double-V Groove Weld

Fig. 13—Double Bevel Groove Weld

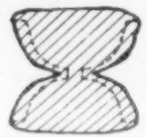


Fig. 14—Double-U Groove Weld

Fig. 15—Double-J Groove Weld

Fig. 16—Fillet Weld

Fig. 12—Double-V Groove Weld | Fig. 13—Double Bevel Groove Weld | Fig. 14—Double-U Groove Weld | Fig. 15—Double-J Groove Weld | Fig. 16—Fillet Weld

Fig. 17—Bead Weld

Fig. 18—Plug Weld

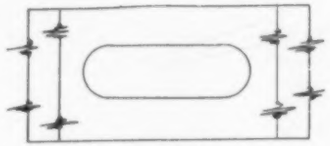


Fig. 19—Slot Weld

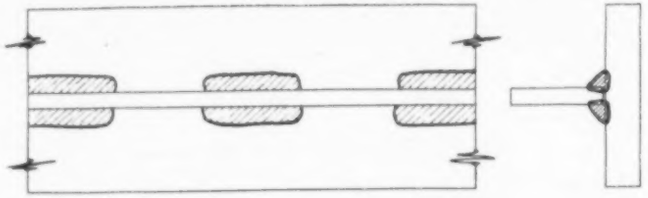


Fig. 20—Chain Intermittent Fillet Welds

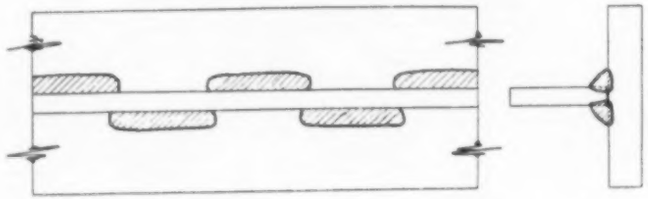


Fig. 21—Staggered Intermittent Fillet Welds

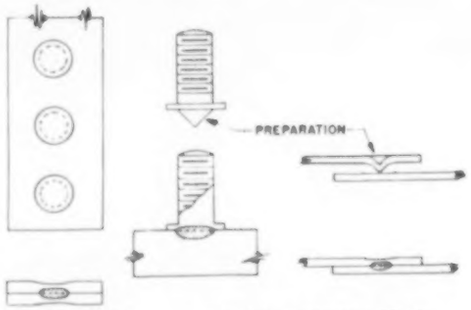


Fig. 22—Spot Weld

Fig. 23—Projection Welds

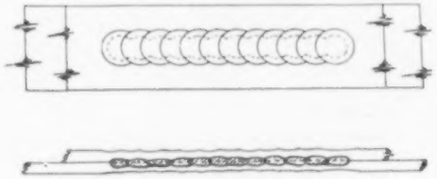


Fig. 24—Seam Weld

Fig. 25—Flash (Butt) Weld

Fig. 26—Edge Preparation

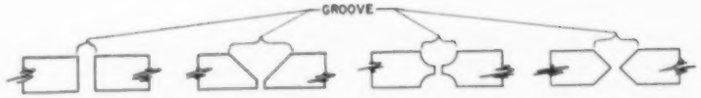


Fig. 27—Groove

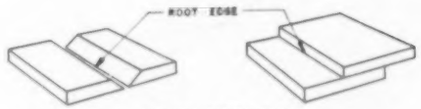


FIG. 28 ROOT EDGE

FIG. 29 ROOT FACE

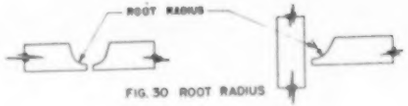


FIG. 30 ROOT RADIUS

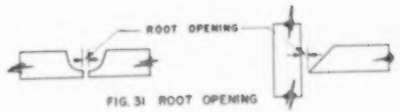


FIG. 31 ROOT OPENING

FIG. 32 GROOVE ANGLE

FIG. 33 INCLUDED ANGLE

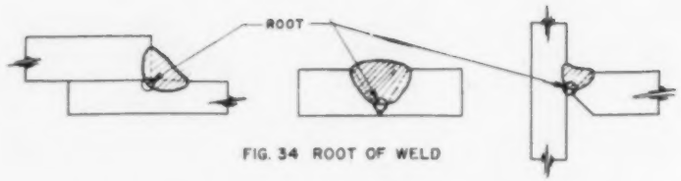


FIG. 34 ROOT OF WELD

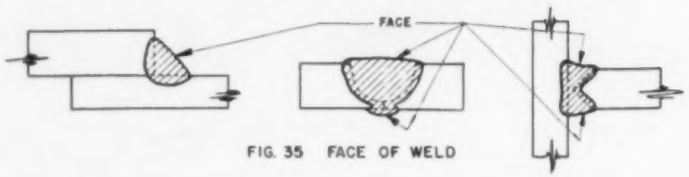


FIG. 35 FACE OF WELD

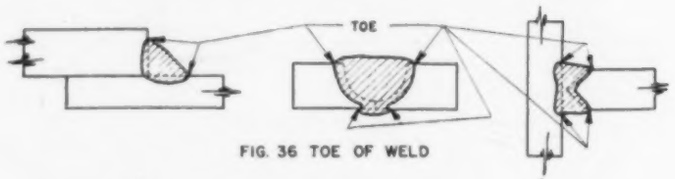


FIG. 36 TOE OF WELD

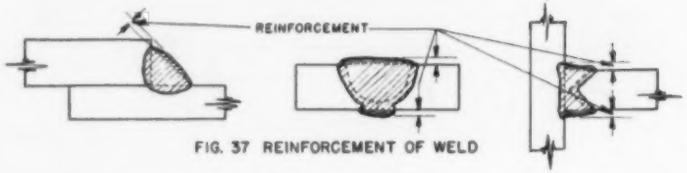


FIG. 37 REINFORCEMENT OF WELD

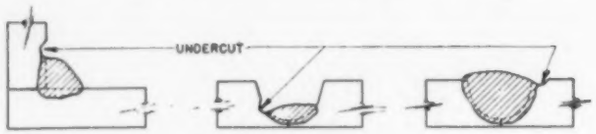


Fig. 38—Undercutting

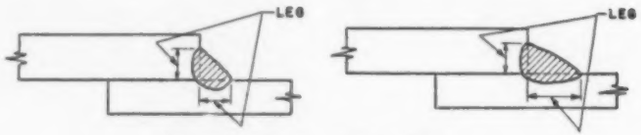
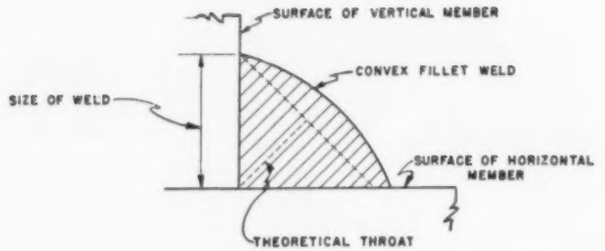
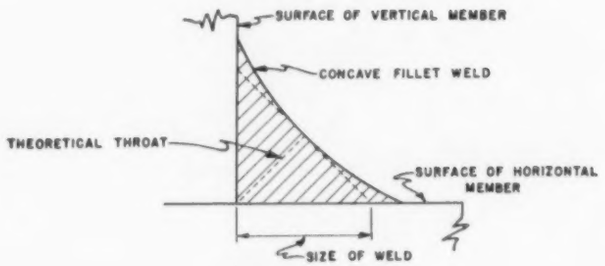


FIG. 39 LEG OF FILLET WELD

FIG. 40 THROAT OF FILLET WELD





$$\text{SIZE} = \frac{\text{THROAT}}{.707}$$

NOTE
THE SIZE OF A FILLET WELD IS THE LEG LENGTH OF THE LARGEST INSCRIBED RIGHT ISOSCELES TRIANGLE.

FIG. 41 SIZE OF FILLET WELD

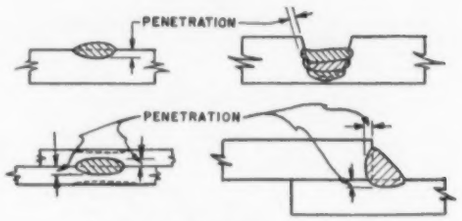


FIG. 42 PENETRATION

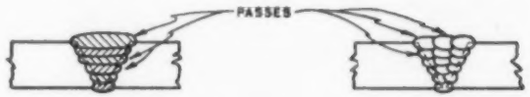
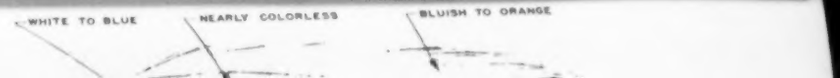


FIG. 43 PASSES

FIG. 44 LAYERS



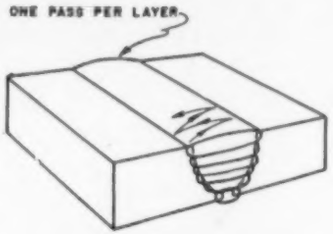


FIG. 45 WEAVING

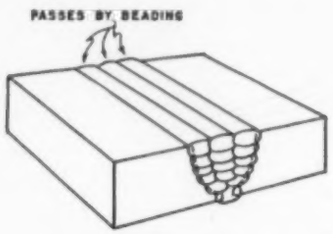


FIG. 46 BEADING

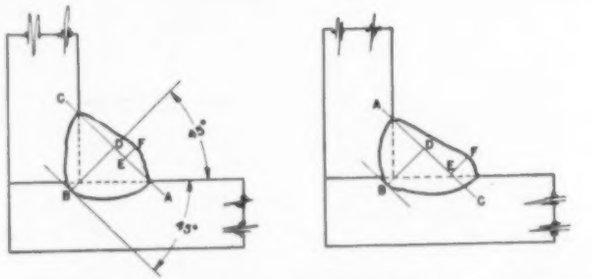


Fig. 47—Convexity Ratio

FIG. 44 LAYERS

FLAME AS SEEN WITHOUT WELDERS GOGGLES

FLAME AS SEEN WITH WELDERS GOGGLES

Fig. 48—Neutral Flame

FLAME AS SEEN WITHOUT WELDERS GOGGLES

FLAME AS SEEN WITH WELDERS GOGGLES

Fig. 49—Oxidizing Flame

FLAME AS SEEN WITHOUT WELDERS GOGGLES

FLAME AS SEEN WITH WELDERS GOGGLES

Fig. 50—Reducing Flame

Two Welded 20-Ton Screw Luffing Cranes

By D. T. STREITHOF*

AN EXTREME margin for safety in the handling of heavy crane lifts over expensive complete assemblies is embodied in the design of the two new screw luffing, full-revolving tower cranes recently built by Dravo Corporation and installed in the yards of the Newport News Shipbuilding & Dry Dock Company, Newport News, Virginia.

It is well recognized that the advance of welding in ship construction has resulted in the prefabrication of large assemblies. This condition and the installation of heavy equipment and machinery, requires heavy crane capacity alongside the building ways.

The cranes have a 125-foot boom and a main hoist equipped with an operating capacity of 20 tons at a radius of 62 feet and 10 tons at a radius of 93 feet. An auxiliary hoist provides a capacity of 8 tons at a radius of 113 feet. Mounted on trestle runways, with train rails spaced at 20-foot centers, they provide adequate flexibility for heavy-duty shipyard service.

The outstanding feature is the screw luffing mechanism which has been made practical by the use of welded construction in forming a triangular boom.

Experienced structural engineers will appreciate the difficulty that would have been presented had riveted details been employed to form a boom of this shape. Obviously, the practice of welding is better adapted to the problem. The methods used to accomplish the various connections are here illustrated.

The boom has been connected to the longitudinal trusses. Chord members of the boom were made of wide flange beam sections with web members of double-angle star-shape construction. Gussets were arranged normal to the webs of the chords, the top flange of the bottom chord members being slotted to permit the continuity of the gussets.

The top chord splice is a most interesting detail, the function of which is to transmit a tension stress of two hundred thousand pounds from a single 8 inch wide flange beam to two 10-inch standard I beams. The transition was accomplished by welding the three primary members involved to a common splice block inserted between the webs of the two beams. A vee-shaped section was removed from the webs of these two beams and the resulting perimeters continuously welded to the splice block. An integral trapezoidal boss on the top and bottom of the splice block, passes through and continuously welds to the flanges of all three beams. A portion of the web of the 8-inch beam is removed to permit the entry of the splice block which reduces uniformly in thickness from the splice point to its termination. Likewise the depth of the splice block tapers at this point which, when inserted between the flanges of the 8-inch beam, forms a smooth transition of the connecting members. The net result is a "streamlined" splice, simple and neat in appearance, yet highly efficient.

The boom was prefabricated at Dravo Corporation's Neville Island works for accuracy and alignment, and erection bolts provided for the various shipping units to insure the accuracy and to expedite field assembly.

The luffing mechanism consists of a screw arrangement working on two non-rotating nuts mounted in steel trunnions. Having an over-all length of 35 feet, the screw is made of forged nickel steel, normalized and flanged.

The screw has a lineal travel speed of 2.15 feet per minute. One and two-thirds minutes are required to change the boom from maximum to minimum radius. The screw is motor-driven through a gear reduction unit designed so that the boom cannot change position except when the mechanism is in operation, an added factor for safety. Upper and lower boom positions are protected by an electric limit switch, with slow-down and final stop arrangement.

Driven independently, the two hoisting units are mounted on an integral welded base, the main hoist

* Engineer, Dravo Corporation.

Fig. 1—Twenty-Ton Screw Luffing Electrically Driven Crane, Showing the Boom in High Position. The Screw Luffing Mechanism Provides a Positive, Safe and Quick Means of Load Spotting

Fig. 2—The Triangular Shape of the Boom, Found to Be Most Suited to the Use of the Screw Luffing Principle, Was Made Practical Through Modern Welding Design and Practice

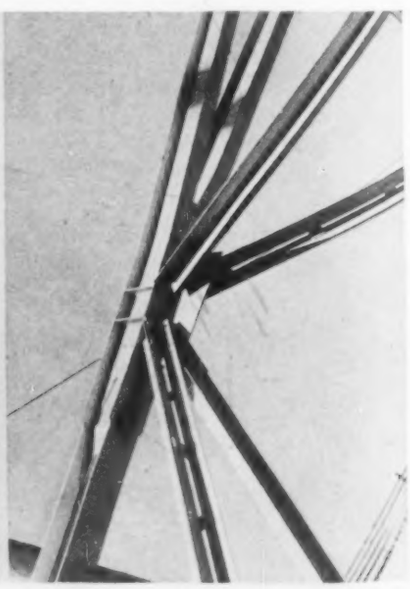
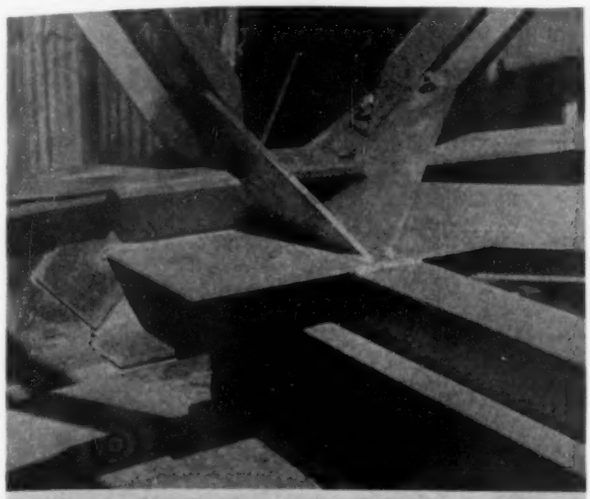


Fig. 3—A Most Interesting Detail Is This Top Chord Splice, the Function of Which Is to Transmit a Tension Stress of Two Hundred Thousand Pounds

Fig. 4—Boom Gussets Are Arranged Normal to the Webs of the Chords, the Top Flange of the Bottom Chords Being Slotted to Permit Continuity of the Gussets



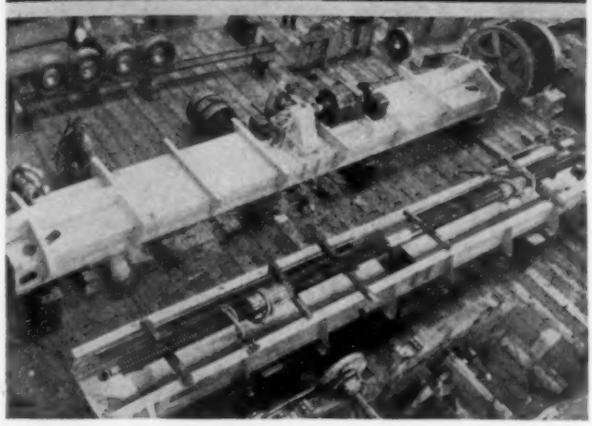


Fig. 5—A 35 Foot Long Screw Mounted in a Welded Steel Case Is Motor-Driven Through a Gear Reduction Unit. This View Shows the Luffing Mechanism in the Process of Assembly at Dravo Corporation's Neville Island Plant

drum of Mayari cast iron and grooved for two $^{7}/_{8}$-inch wire rope lead lines, the load block being reeved for four parts of line. The mechanism is motor-driven through a double set of spur reductions giving a rope speed of 78 feet per minute.

The auxiliary hoisting unit is driven with a motor identical to that driving the main drum. The drum is grooved for a single $^{7}/_{8}$-inch wire rope. The auxiliary block is reeved for two parts of line, with non-spinning type of wire rope and has a rope speed of 205 feet per minute.

Tower structure 35 feet high above the runways has a wheel base of 35 feet and a travel speed of 350 feet per minute in still air. Tower is of welded design, built of heavy structural shapes rigidly braced on all four sides. Two double-jaw automatic rail clamps mounted in the center of each tower leg, are designed to hold the crane against a 200 mile-per-hour wind.

The top of the tower forms a sturdy base on which is mounted the lower rail circle, the rotating track and the center stediment casting.

The center stediment, consisting of bronzed bushed male and female part, is designed to absorb all of the horizontal forces. The rocking mechanism provides the machine with a rotating speed of $1^{1}/_{2}$ r.p.m.

The rotating structure is supported on a circular roller path of high carbon, rolled steel, double-flanged wheels. Bronze-bushed, they are mounted on steel pins assembled in a double-channel circular cage. Heavy rails form the upper and lower rail circles, the complete assembly resulting in an unyielding level turntable.

The rotating platform is of all-welded construction and consists substantially of four longitudinal girders and two vertical trusses with crossbeams for supporting machinery and counterweight.

The crane machinery, control panels and operator's controls are housed in a neat all-welded steel cab located on the rotating platform. All the motors are provided with solenoid brakes and full magnetic controls, resulting in a positive and safe control over each crane movement and operation.

Discussion Rigid Frame Structures

By MARTIN P. KORN*

THE report by Ambrose H. Stang and Martin Greenspan entitled "Strength of a Welded Steel Rigid Frame" which appeared in the January issue of THE WELDING JOURNAL is of timely interest and importance. Under the heading "Conclusions" appears the statement, "The largest stresses occurred at the inner corner of the frame and appeared to be a local effect due to the presence of the stiffener." That statement is subject to misunderstanding.

The largest stresses occurring there were due only to the shape of that frame. If no stiffener were used the largest stresses would still have occurred in that same locality, the failure of the frame would have occurred in that same locality and the failure would have resulted from buckling of the web and flange in that same locality.

The effect of the stiffener was to transfer a certain amount of stress from the sharp inner corner where the highest stress concentration occurred to the less stressed areas in the body of the knee. That strengthened the knee and increased the strength of the frame for the strength of that frame was limited to the strength of its knee. The stiffener made possible a maximum loading of 153.6 kips. Without the stiffener the maximum loading before failure would have been considerably lower.

* Consulting Engineer.

REPLY BY M. GREENSPAN, JR.†

We agree that if no stiffener had been used, the largest stress would have occurred in the same place, namely at the inner corner of the knee; but, since the stiffener restrained motion of the inner corner of the knee toward the outer corner, the working-load stress at the inner corner was higher than it would have been if the stiffener were absent. The theory given in Research Paper RP1130 of the National Bureau of Standards (Vol. 21, September 1938) indicates that if the stiffener were absent, the distribution of normal stress on the section nearest the corner (Fig. 7 of the present paper) would have been linear, that is, there would be no sudden increase of stress at the inner corner.

† Physicist, National Bureau of Standards.

STANDARDIZED RATINGS FOR Resistance Welding Contactors*

By F. H. ROBY†

FOR several years contactors have been applied to resistance welding machines in accordance with rule-of-thumb methods developed by individuals or equipment manufacturers. No *standardized* rating data was available. Confusion in the form of conflicting recommendations and questionable installations naturally resulted.

Recognizing the need for unified action, the National Electrical Manufacturers' Association appointed a subcommittee to study the problems involved and present recommendations for standardized rating data. A set of curves similar to the one reproduced in Fig. 1 were developed for the use of any one concerned with contactor rating problems. The complete set includes eight different curves, identified in Fig. 2.

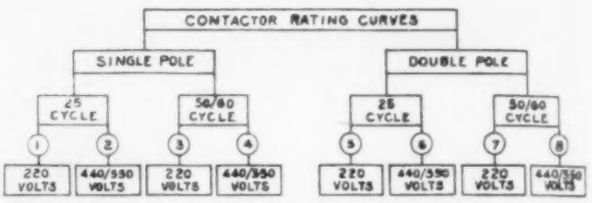


Fig. 2—Identification of the Eight Rating Curves for Non-Synchronous Welder Contactors

FORM OF CURVES

Now that rating curves are available, the procedure for selecting a contactor to be used in connection with a specific resistance welding machine is firmly fixed. However, three characteristics of the application must be determined before the rating data can be used. They are: (1) Welding transformer primary amperes, (2) approximate time in cycles for a single weld and (3) the number of welds to be made in a given interval.

Inasmuch as there are three variables which contribute to the final contactor selection, the curves must be of a slightly complex form. In fact, the allowable ratings for a specific contactor type and size are expressed by a family of curves. Each curve within the family represents a different welding time and its contour is determined by plotting the average number of welds made per unit of time against the load (in amperes primary current) that the contactor can safely handle under the stated condition.

At first glance it would seem that welding time and number of welds made per unit of time could be combined into one variable called "Duty Cycle," thereby eliminating the complex nature of the curves. However, contactor ratings are limited by the temperature of the current carrying parts. If they become overheated, too rapid deterioration and occasional "sticking" together of the contact tips might result. Heat is generated at two points: (1) in the current carrying parts and (2) in the arc drawn at the conclusion of each operation. Thus, it becomes necessary to divide the duty cycle into corresponding component parts: (1) length of each weld and (2) number of operations made per unit of time.

* This is one of a series of articles being sponsored by the Resistance Welder Manufacturers' Association.

† Square D Company, Milwaukee, Wis.

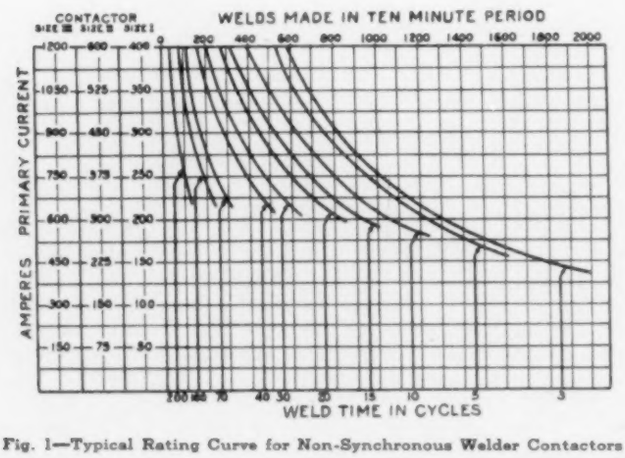


Fig. 1—Typical Rating Curve for Non-Synchronous Welder Contactors

DETERMINATION OF VARIABLES

The number of welds made per unit of time is fixed by production requirements as well as the nature of the work and equipment. A ten minute averaging period has been selected to include loading time—the interval during which the material is being handled and no welds are made. Selection of a longer interval could result in overheating if all the welds were made in rapid sequence during one small part of the allotted interval. Fortunately the averaging period is not critical, since a considerable interval is required to overheat the rather heavy copper current carrying parts.

The welding time can be estimated on the basis of power available as well as the kind and thickness of the work to be welded. Handbooks on resistance welding contain general information relating to this subject, and the machine manufacturer's experience will permit an even closer estimate of this factor. If a special application is involved, sample welds are usually made before a production machine is selected and the power required, as well as the welding time needed, are easily determined.

Fig. 3—Single and Double Pole Non-Synchronous Welder Contactors

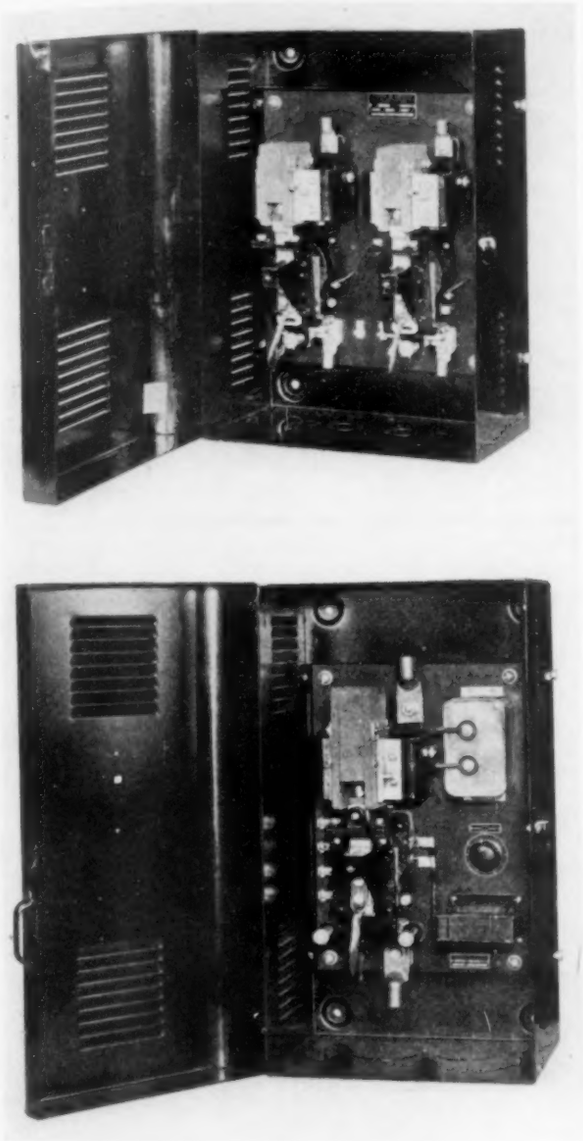


Fig. 4—SYNCHRO-BREAK Welder Contactor

The rating of a resistance welding machine is usually expressed in kva. at a given voltage on a one half time duty cycle basis. A typical welder duty cycle might be as low as 4% and is more probably about 10%. Then transformers can deliver for intermittent periods more than rated current without exceeding the temperature rise on which the original rating was based. For instance, a 30 kva., 220 volt transformer would be expected to draw 136 amperes (calculated by dividing 30,000 volt-amperes by 220 volts) primary current on a 50% cycle basis without over-heating. Since the heat generated is proportional to the product of current squared, resistance and time, the same transformer could theoretically draw as much as $\sqrt{25}/\sqrt{2}$ of 3.5 x 136 amperes on a 4% duty cycle basis without exceeding the original temperature rise. In a similar manner an allowable primary current of 2.25 x 136 amperes could be drawn on a 10% duty cycle. Thus, the load expressed in primary amperes can be roughly determined by multiplying the quotient of rated kva. voltage by a factor of from 2.25 to 3.5, depending upon the estimated duty cycle. More exact load data is preferable when it can be obtained from the machine manufacturer or by means of actual measurements.

SELECTION OF RATING CURVES

Figure 2 indicates eight individual rating curves. Several decisions must be made before one is applied. The first concerns the type of contactor. Nearly all welding tranformers are wound single phase. Either single or double pole contactors (see Fig. 3) can be used, if rated accordingly. Double pole units are rated higher than single pole contactors of equivalent size. The two gaps in series provide two points at which the energy in the arc can be dissipated and the voltage across each gap is reduced. A double pole contactor opens both sides of the line leading to the welding transformer and may be preferred for that reason. On the other hand, single pole devices are usually considered safe when used with a two pole, manual disconnect switch.

The choice of contactor type reduces the number of applicable rating curves to four. Separate curves for each different voltage and frequency must be provided because these factors materially influence the length of arcing period. Ratings are reduced for the higher voltages and lower frequencies.

USE OF CURVES

Assume that you are required to select a two pole contactor for use with a welding machine rated 75 kva., 440 volts, 60 cycles. A production estimate indicates that 780 five-cycle welds will be required within a ten minute operating period. 75,000 volt amperes, divided by 440 volts, equals 170 amperes. This value multiplied by 2.5 (compensating for an estimated intermittent duty cycle) equals 425 amperes maximum load that can be drawn from the transformer without exceeding its rating. Select the 5 cycle curve of the "family" shown in Fig. 1. Follow the curve to a point on the abscissa (horizontal reference axis) equivalent to 780 welds in a ten minute welding period. Directly across from that point on the ordinate (vertical reference axis) read a maximum allowable rating of 290 amperes for a size 1 contactor. It is obviously not large enough for a 408

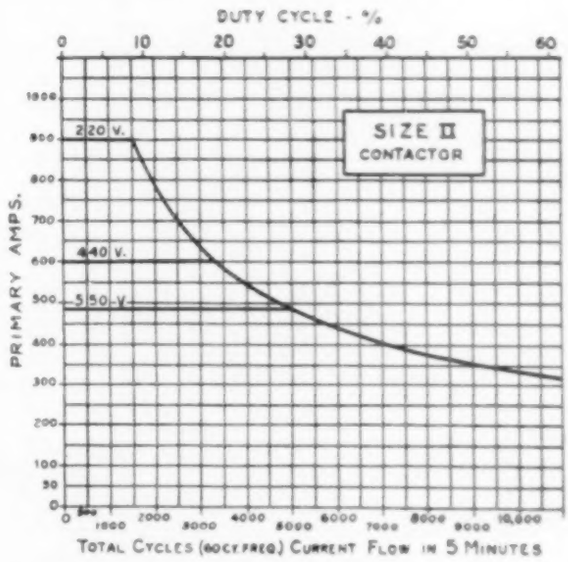


Fig. 5—Typical Rating Curve for SYNCHRO-BREAK Welder Contactor

ampere load. However, continuing to the left on the same line, it is found that a size 2 device is capable of handling a load of 435 amperes under the stated conditions. It represents the proper selection of equipment.

Contactors are identified by the size numbers 0, 1, 2, 3, 4, 5 for 50, 100, 150, 300, 600 and 900 amperes nominal ratings, respectively. The nominal rating represents the load which can be carried continuously without exceeding a specified temperature rise on current carrying parts. It has little meaning except for comparison purposes, since resistance welding service is usually intermittent in nature. Actual ratings must be determined from the standardized rating curves discussed above. Their derivation has both theoretical and practical foundation, since the effect of each of the factors mentioned was determined in an elaborate series of laboratory tests. Emperical formulas were developed from the test data obtained. The rating curves have been plotted from those formulas.

SYNCHRO-BREAK CONTACTORS

Less complicated rating data is applicable to a welding contactor that has been synchronized to open without drawing an arc at its contact tips. Figure 4 illustrates such a device.

It was pointed out in earlier paragraphs that where non-synchronous contactors are involved the heating upon which ratings are based has two sources—Losses (1) in current carrying parts and (2) in the arc drawn at the conclusion of each operation. For that reason the duty cycle factor is divided into corresponding component parts of (1) length of each weld and (2) operations per unit of time. If arcing at the contact tip is eliminated, there is no reason for such a division and the load in primary amperes can be plotted directly against duty cycle expressed in percentage or in the number of conductive cycles per unit of time.

Duty cycle is best expressed in terms of conductive cycles per unit of time. Assuming the length of each weld, as well as the number of welds required per unit of time are known, these factors can be multiplied together to determine the total cycles current flow in five minutes. The five minute period is an arbitrary selection used to insure the inclusion of a suitable number of loading periods in the computed duty cycle. The curves also indicate duty cycle expressed in terms of percentage, to avoid the necessity for re-figuring if such values are already available.

The maximum load represented by a given transformer size must be expressed in terms of amperes primary current. A method for estimating this value has already been given. Once it is known the proper contactor size can be selected from the rating curves provided for each of several contactor sizes. For example, a welding machine equipped with a 100 kva., 440-volt transformer having a maximum primary current of 540 amperes, is expected to make 150 fifteen cycle welds within a five minute interval. The total period of current flow within the interval is equal to 150 × 15, or 2250 cycles. Consult Fig. 5. Follow a vertical line from a point on the horizontal axis equal to 2250 cycles until it crosses the heavier line representing the contactor heating curve. Notice that the curve is "broken off" at different points for 220, 440 and 550 volt ratings. When the intersection of the two lines has been located, follow a horizontal line to the primary ampere scale at the extreme left of the curve. The intersection point is thus observed to be directly opposite from an allowable rating of 600 amperes for the duty cycle under consideration. Since this value exceeds the actual primary current of 540 amperes, a size 2 contactor is suitable for the application. If the actual current had exceeded the value read from the curve, it would have been necessary to consult similar curves for larger contactors, to determine which of these provided the necessary capacity.

CONCLUSION

By making available standardized rating data for resistance welding contactors, the manufacturers of such equipment hope to encourage proper application and insure against faulty operation as the result of overload. Experience has indicated that a conservative rating policy pays large dividends in the form of materially increased contact tip life and freedom from expensive maintenance operations. Although there is a natural tendency to select the least expensive piece of equipment, the small saving in first cost is nearly always more than offset by increased operating costs.

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WELDING METALLURGY

By O. H. HENRY and G. E. CLAUSSEN

A series of lectures prepared for presentation in a fundamental course of metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the AMERICAN WELDING SOCIETY. To be published serially in The Welding Journal. Available in Pamphlet Form—47 pages Journal Size. Copiously Illustrated. $1.00 per copy. Special Prices quantity lots ten or more.

Part IV—How Crystals Grow from Other Crystals

If crystals could not grow from other crystals, annealing would have not nearly its huge effect in softening a metal, and welded steel would have not nearly its characteristic ductility. The crystals of a pure solid metal may change over to another set under two conditions:

1. One type of crystal, for example, cubic, may change to another type, say, hexagonal. A change of this sort, called a Transition or Transformation, occurs at a single temperature, the transition point, in a pure metal, in the same way that the change from liquid to crystal occurs at a single temperature, the freezing point. The reason one type of crystal is stable above the transition temperature is that it has a lower free energy than the other type.

2. Permanently distorted crystals, upon their temperature being raised, recrystallize to undistorted, equiaxed crystals. The recrystallization temperature is the temperature at which the distorted grains are replaced by equiaxed grains. The greater the degree of permanent distortion, called cold work, such as hammering steel at room temperature, the lower the recrystallization temperature. If the crystals are distorted above their recrystallization temperature, (this type of distortion is defined as "hot work," such as forging red hot steel) they recrystallize at once.

Let us return to the transition. At the transition temperature we have, instead of nuclei forming in a melt, nuclei forming in a solid crystal. There are no crucible walls, but the original crystals have edges and corners that can supply the energy to set off the formation of new crystals. Hence, the nuclei usually form at the edges of the original crystals, called the crystal boundaries, or more simply, grain boundaries. During cooling, the numerous new equiaxed crystals grow until all the large old crystals have been absorbed, before the temperature falls once again. A similar process is repeated on heating but transitions usually are slower than freezing or melting because crystals are more rigid than liquid. If there are foreign particles in the pure metal, such as alumina in steel, they also may act as nuclei during a transition. Undercooling, while more accentuated with a transition than with freezing, leads to more complex situations than with freezing. In the absence of undercooling, the change in temperature dur-

ing cooling through a transition, for example from gamma iron (face centered cubic crystals) above 900° C. to alpha iron (body centered cubic crystals) below 900° C., has the same appearance as a cooling curve during the freezing of pure iron.

We will find that, if impurities or alloying elements are added to a metal, they affect the cooling curves during melting and freezing in ways that obey the same laws as the effects of these elements on any transitions that may occur. Transitions, as a matter of fact, are the exception rather than the rule. Nickel, copper, zinc, tungsten and lead, for example, have no transitions. Iron, tin and cobalt do, and the transition at 900° C. accounts for a great deal of the usefulness of iron.

Recrystallization, obviously, is different from transition. Recrystallization can occur only when cold worked metal is heated to the recrystallization temperature. Transitions, on the contrary, occur every time a metal is heated or cooled through the transition temperature. The product of recrystallization is a crystal of the same type as the original undistorted crystal. On the other hand, the type of crystal changes as the result of a transition Both transition and recrystallization have two elements in common. (1) The nuclei are extremely small, and (2) the transition and recrystallization may be so controlled that the grain size is finer than the original grain size.

Critical Points

In discussing transitions, we found that during cooling heat is evolved at the transition temperature. The metal also expands. On these two facts are based our methods of studying and controlling transitions, namely: thermal and dilatometric analysis. By thermal analysis; that is, by measuring the temperature of the metal during the passage of time, we determine evolutions of heat and are able to match them with transitions. Similarly, by observing the change in length of our specimen during cooling or heating we determine the temperature at which transitions occur.

The main interruptions in the normally uniform rate of heating or cooling of a specimen are known as critical points. Thus, the transition at 900° C. in iron is known as the A_3 critical point. If the A_3 point is determined during heating the temperature of the transition is called the Ac_3 point (c signifies Chauffage, which is the French word for heating), and is higher than the point on cooling, which is called Ar_3 for a similar reason.

Besides the A_3 critical point in iron and steel there are four others:

A_0 at 200° C.—a magnetic change in iron carbide. Below 200° C. iron carbide is magnetic. The critical point is not observed in iron free from iron carbide.

A_1 at 720° C.—the Eutectoid transformation, which will be explained later. The A_1 point is not observed in carbon-free iron.

A_2 at 768° C.—a change in the magnetic and a few other properties of Alpha iron.

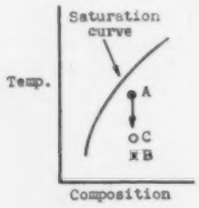

Fig. 10—Saturation and Precipitation

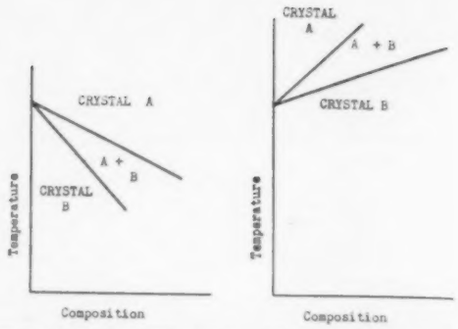

Fig. 11—The Two Possible Effects of an Alloying Element on the Melting Point of a Pure Metal. At the Left the Alloying Element Lowers the Melting Point, at the Right, It Is Raised. In Both Instances the Alloying Element Causes Melting and Freezing to Occur Over a Range of Temperatures

A_4 at 1400° C.(in pure iron)—the change from Gamma to Delta iron on heating and vice versa on cooling.

Other Crystal Changes

When a solid metal contains impurities or alloying elements, they may dissolve in it. The dissolved elements occupy places in the crystal lattice, which changes slightly in size but not in type. The atoms of the added element may replace some of the iron atoms in the lattice, or they may fit into vacant spaces if they are small atoms, such as carbon in Gamma iron.

If conditions are favorable, the alloying elements may come out of solution; that is, precipitate. In some way not yet fully explained, enough atoms of the impurity or alloying elements get together to form a crystal nucleus, frequently at a grain boundary. They form the nucleus, of course, only if the solid crystalline solution has become supersaturated, perhaps by fall in temperature. Having exhausted the supply of alloying element within its immediate vicinity the nucleus ceases to grow, others being formed elsewhere. As a result, the initially homogeneous crystals of solid solution become more nearly pure crystals of the same type, but dispersed through them are crystals of a different type containing the excess alloying element.

Suppose we rapidly cool the supersaturated solution to *B*, Fig. 10. At low temperatures metal crystals become increasingly rigid, and, depending upon the metal and the alloying element, the alloying element may be retained in the supersaturated solution. Precipitation does not occur. If the temperature then is raised, the atoms become less rigidly held in the lattice and precipitation may occur at some temperature *C* below the saturation curve. At this temperature the atoms still are more rigid than at *A* and, in consequence, the crystal nuclei containing the precipitating element can draw from a less extensive vicinity and the nuclei are smaller than at *A*. But they are, for that reason and because the degree of supersaturation is greater, more numerous at *C* than at *A*.

The process we have described is known as precipitation hardening. If supersaturation is relieved at room temperature without reheating but after the passage of an amount of time known as the inoculation time, the process is known as age hardening. The precipitate may be a nearly pure metal, such as the precipitate of copper from an alloy of iron with 1% copper at about 500° C., or the precipitate may be a compound; for example, $CuAl_2$, which precipitates from a quenched alloy of aluminum with 4% copper at room temperature.

The three conditions under which a crystal may grow from another crystal are:

(1) transition, (2) recrystallization and (3) precipita-

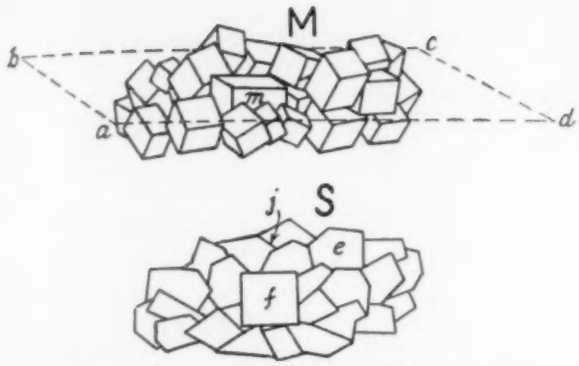

Fig. 12—Lack of Uniformity Among the Grains of a Metal (Richardson)
The lower diagram is a view from above of the heap of crystals after it has been cut along plane a b c d and the upper half removed

tion. Obviously precipitation cannot occur in pure metals. Recrystallization occurs alike in pure metals and alloys, the same laws being obeyed in both. When an alloying element is added to a metal exhibiting a transition, the transition no longer occurs at a single temperature. Instead, the transition starts at one temperature, continues over a range of temperature and is not complete until another temperature has been reached, Fig. 11.

Grain Size

When a liquid metal freezes, crystals usually grow from a large number of nuclei. Each crystal contains huge numbers of atoms rigidly held at fixed center-to-center distances. The many-sided crystals are heaped about, Fig. 12. The crystals may all have the same size, or there may be a wide range of sizes. On the average, the crystals, or grains as they are called, may be large or small. Both size and size distribution have an important effect on the properties of steel and other metals. Grain size is measured by microscopic examination of a polished and etched section of the steel. If we imagine that the dotted plane in Fig. 13 is the plane of the opaque metal specimen we are observing, we see, not the three-dimensional crystals, but the two-dimensional pattern of the grain boundaries. The plane we are examining may cut one grain through the middle, which will give the impression of a large grain, whereas another grain will be cut through one corner, which will give the impression of a small grain. In our specimen, we see, therefore, not the largest cross section of every grain, but some intermediate cross section, whose area, averaged over all the grains we see, is only a fraction of the maximum cross

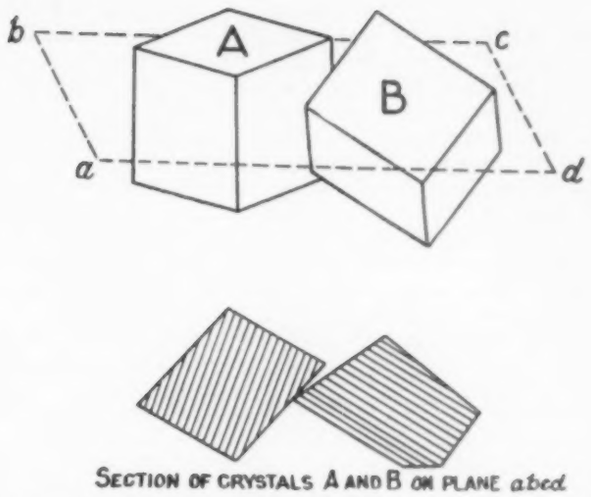

Fig. 13—The Structure Observed in the Microscope Is That of a Plane Cutting Grains at Random (Richardson)

section of all the grains. The observed average area is the best we can do and we, therefore, call it the grain cross section. The observed average area is then converted to grain size in terms of number of grains per square inch. In steel the average grain diameter may be in the neighborhood of 0.001 inch, and the grain size will be about 1,000,000 grains per sq. in. It is the custom to quote grain size as the number of grains in a square inch of specimen magnified 100 diameters. On the basis of 100 ×, 1,000,000 grains per sq. in. of specimen would become 100 grains per sq. in. of micrograph.

The importance of grain size in welding will become evident later. As a general rule, coarse grained steel is more brittle than fine grained, which is usually stiffer and more difficult to machine.

Questions

1. Draw a picture of the atoms in a crystal in which there is a nucleus of another type of crystal.
2. Explain the precipitation of a crystal containing several types of atoms in another crystal, for example, the precipitation of iron carbide in iron.
3. Describe three ways in which grain size may be measured.
4. How will recrystallization affect the grains in the vicinity of a weld in cold rolled metal?
5. What is the difference between the terms "crystal" and "grain?"

Bayonne Technical High School Welding Department

By S. H. MOIR*

THE Welding Department was created by the Director, Mr. Edward Berman, a graduate of Yale, and a man who has wide experience in Vocational work.

The text book "Steel," by Campbell, The Lincoln Procedure Handbook, The American Welding Society Handbook, and THE WELDING JOURNAL as supplementary material, keep the students informed regarding the latest developments in welding.

Theory classes meet five times a week for one-hour periods. Three-hour laboratory classes meet five times a week, wherein students get actual practice in welding under expert supervision.

Theory for the first year consists of a study of iron and steel as to production and processing. Emphasis is placed on the Physical constituents of steel in preparation for courses later which are more closely related to welding. "Steel," by Campbell, is used as a text-book in this course. In the laboratory the student learns the care and handling of welding equipment.

The shop equipment consists of two rows of booths. One is a battery of multiple unit arcs operated by a

* Welding Instructor.

generator in the corner of the shop. The other row includes only independent units, both portable and stationary. These machines include four different makes. Each student is assigned to a booth at the outset. He learns the construction and operation of it, then he is moved to another machine. This is continued until all the different types of equipment are familiar to the student. The gas welding shop has fifteen separate torches as a multiple unit operated from an acetylene manifold and an oxygen manifold, each in a separate room. There is also a separate cutting apparatus which each student learns to use. He is expected to develop a fair ability both as a gas and arc welder in flat, vertical and overhead positions on low-carbon steel and must be able to do a good job on cast iron, being subjected to an AMERICAN WELDING SOCIETY and U. S. Naval welding test before being allowed to graduate.

Considerable time is spent on the heat treatment and identification of metals. Concurrent with this course, the student is required to study forge and heat treatment of metals. Here he studies the reaction of steel to heat treatment and gets actual experience in forging and heat treatment of steel. The second year consists of a study of strength of welds, stress concentration warpage, cost estimation, flame cutting, flame hardening, different types of welding construction, characteristics of welding generators, the weldability of different metals and the technique used in welding each, and design of welded machinery and structure, codes and symbols. Laboratory is a continuation of the first semester. Students are required by the end of the year to pass qualification tests in all positions—these tests are carried on in much the same manner as they are in industry with the purpose of acquainting the student with the methods now in use, so that they can pass any qualification test they may encounter.

During the tests, students are divided into groups of two, one acting as welder, the other as inspector. As the weld is being made, the inspector observes and records any mistakes that may be made by the operator. This data is correlated with any flaws that may be found in the weld when it is tested. The test plates are cut into inch wide bars across the weld and subjected to a series of tests to determine the strength and soundness of the weld. The student not only improves his own welding but also learns to judge the ability of other operators both in the manipulation of the gas torch and electric holder, and by examination of the finished weld. This is experience that will serve him well should he ever become a welding inspector.

Reports are written on each welding exercise. Aluminum, brass and iron base alloys are welded by both the arc and acetylene, and comparisons are made as to the relative strength, ductibility, appearance, speed and cost of welding, etc. The third year is devoted to welding design and special technique using the American Welding Society Handbook with occasional reference to the Lincoln Procedure Handbook.

In addition to regular welding exercises, students fabricate many welded structures and repair broken machine parts for other departments. In conjunction with welding cast irons, the students can now obtain actual experience in welding automobile heads which are supplied by a local steel exchange. Heads which are satisfactorily welded will go back into service with the student's name stamped on it. Codes and Symbols are taught throughout the three years. It can readily be seen that the technical training is not easy. Consequently, those students only moderately interested in welding soon drop out and are replaced shortly by boys who are willing to work after a semester of welding. Those who show little aptitude are advised to take some other work. Many of the regularly enrolled students are young men with the ambition of becoming welding engineers and, in addition to their regular welding curriculum, are taking up some phase of engineering, and substituting engineering courses where permissible.

Although we are concerned here primarily with welding, other supplementary courses contribute to make the student well informed generally as well as manually skillful. Through the study of English, Economics and Industrial History, he learns how these factors affect him and his employer.

Drafting and Blue Print Reading are studied with care until fabrication can be practiced from blue prints. Shop mathematics and shop science are included in the course. Upon completion of the course, a Technical High School diploma is awarded.

A graduate welder is a skillful operator, an intelligent blue print reader and a rational individual who understands and appreciates the problems of his industry. In short, we offer a well trained, valuable man.

Because the welding course is young, we have only had thirty graduates to date. Each student was a hard worker and is now an employee.

WELDING AND THE BUSINESS of Shipbuilding*

By E. C. RECHTIN†

UNTIL about 1840, practically all ships were of wood, during the succeeding decades, a gradual transition to iron and then steel construction was made. . . . During a century, therefore, the art of riveting ships was being developed and perfected to a high degree. . . . Then some thirty years ago—along came a new process—considered at first as a handy tool for patching and repair work. It gradually grew in importance and adaptability until about ten years ago when it began to be recognized as a major departure in shipbuilding technique. Welding, thus, is a comparative newcomer in our profession, but is having a profound and far-reaching effect, on not only the technical, but likewise on the business side of shipbuilding.

Our guests, the Society of Naval Architects and Marine Engineers are deeply interested in any change affecting their profession, particularly when the change

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† Asst. to the Vice-President, Bethlehem Steel Company, Shipbuilding Division, Quincy, Mass.

promises to practically make over many of the accepted techniques which have been successfully followed for years. Our own Society owes its existence to welding, its entry into a vast and basic industry like shipbuilding, raises problems and provides opportunities which are of intense interest.

Consequently, it seemed to me that both guests and hosts would find a survey of the economics of welding in shipbuilding of some value. Although they naturally have different view-points on this subject, there is a community of interest in its general aspects.

When dealing primarily with the economic phase of shipbuilding, we will have to confine ourselves to merchant work. Naval construction is affected by so many factors, that monetary economy cannot be the first consideration.

Merchant shipbuilding is a commercial business and like all commerce, must depend upon a margin of income above cost for its continued activity. So, before you build a ship it has to be sold. The price and cost must have their proper relation for the shipbuilders purpose, but the value of the ship must also be such as to allow the prospective owner in his turn to be able to operate commercially.

"Value" of a ship to an owner embraces far more than its first cost. Its operating characteristics, economy, maintenance costs and cargo carrying efficiency all enter into value. Balanced consideration of these and other factors is leading the prospective owner to accept and in many cases demand a welded ship.

The natural and proper conservative attitude of the shipbuilder is what started the building of welded ships in the field of barges and small tankers. Men are risking their lives going to sea and failure in a ship means far more than monetary loss. Scores—yes hundreds—of successful small welded ships have been built and gradually shipbuilding has progressed into larger and larger units with more and more welding on each succeeding ship. Of course, the question arises—

Is the Welded Ship Cheaper to Build?

This is a question that can hardly find a direct answer. Ships and conditions vary and direct comparisons are impossible. But, it seems a fair opinion at present that properly designed welded ships are not more expensive to build in a properly laid out yard. The builders who are starting in new yards are risking their investment on this opinion—and the old line yards are continually increasing the amount of welding in use. The most important things about welding costs, however, is that they are being reduced. The cost of a riveted ship, expressed in man hours per ton has not changed greatly for many years. There have not been, nor will there be any revolutionary changes in this standardized method with its century of development behind its practice. On the other hand, all our work, all our development in welding is in the direction of reducing costs. Ultimately, the welded ship should cost less than any possible riveted one. First cost, then, is—or soon will be—on the side of the welded ship.

THE OWNER'S VIEWPOINT

But from the owners view, first cost, important as that may be—is not the greatest consideration. To him, a ship is a tool for earning money, and the welded ship is a better money earner. Anything which can save the owner expense, such as costly renewals of corroded structure, or having to pay for oil cargoes being damaged by contamination coming from under riveted angle flanges, is an entry on the credit side in favor of welding. Welding definitely can be utilized to save steel weight, the saving can be employed either to increase margin against corrosion to extend the life of the ship, or can be taken as a direct addition to the cargo carrying capacity where deadweight capacity is particularly desired. In either case, it is of direct benefit to the earning power of the ship.

The Welding Research Committee of the Engineering Foundation has recently published a report which states that a saving of 13% can be readily made in hull steel weight by welding. Machinery for propulsion has also been greatly improved in efficiency in recent years. Hull shapes are better and consequently, a light ship can be built to do the same work—carry the same cargo faster or more cargo at the same speed, than some years ago. These improvements if all translated into deadweight cargo carrying capacity—if the owner wants to make full use of it in this direction, means an increase of some 5% in gross earnings. To be sure welding cannot always claim all of this saving—but at least some of it can be traced back to this change in process, and its saving in weight. The best part of this saving is that it is achieved without increase in first cost and with a probable decrease in operating expense and maintenance.

The saving of 13% mentioned is not always on the high side either. Both here and abroad, this has been exceeded. In an article published last February in *Schiffbau*, Herr Doktor Paul Classen describes the latest developments in German shipbuilding at the Blohm & Voss Shipyards in Hamburg and claims, as a result of the intensive drive for economy of materials under the German four year plan they had made savings amounting to 15.3% in their latest tanker.

At the Fall meeting of the Society of Naval Architects and Marine Engineers, Mr. Pluymert of the Socony Vacuum Company gave figures on the actual achievements in tankers built for his Company. Taking Mr. Pluymert's figures we see that in the latest tanker, a saving of 18% of hull steel weight was made. Part of this saving, in addition to the usual economy of welded structure was due to the use of the Bethlehem Frear System of fluted bulkheads. These bulkheads of course are welded, but their design embraces distribution of material which goes beyond the simple application of welding.

DESIGNING FOR WELDING

Let us now assume we have sold our ship, and are ready to get our plans. Here in the drafting room welding has made drastic changes necessary. It is no longer sufficient for the designing draftsman to know the usual factors of ship design and have a standardized idea of the technique of steel assembly. He *must* know, intimately, and thoroughly, the yard characteristics where the construction is to be done. He *must* know crane capacities and clearance exactly—available assembly and storage areas—and above all the peculiarities and necessities of any special welding equipment used.

It has become increasingly important to design for welding. Many of the troubles that plagued us in the early days of welding can be eliminated almost entirely by intelligent design on the drawing board. This means a clear understanding of the tendency of assemblies to warp and shrink and planning to counteract or allow for this action. It means a knowledge of where and when a particular weld can be made to best advantage, and a sufficient familiarity with strength of welds to give confidence in the selection of reasonable sizes and quantities of welding.

Plans for a welded vessel can be made simpler and clearer than for riveting. The elimination of boundary bars, shell angles, clips, flanges and other details formerly necessary simplifies the plan. It is also very much easier to achieve tightness—the old measures of *Oil Tight* and *Watertight* are gone—a welded bulkhead *is* tight.

But welding also brings its responsibilities to the draftsman. Welding in quantity and size must be clearly shown on the plans—it cannot be left to the judgment of loft or yard. If, as was formerly common, plans are simply marked *weld*—the tendency is to overweld. This greatly increases cost, increases distortion and generally does not greatly increase strength. Since cost of welding varies, roughly, as the square of the nominal size, it is evident that what appears to be a small unimportant increase in bead size actually means a considerable increase in cost.

If, for example, a $^1/_4$-inch weld would do, and the loftsman, left to decide, thinks $^5/_{16}$ inch would be better, the welder, wanting to be sure, makes it $^3/_8$ inch and then an inspector requests $^7/_{16}$ inch to be on the safe side, you have trebled your welding costs and introduced difficulties which would otherwise not exist. Welding sizes should be given on a basis of sound stress consideration, should be approved by the proper authorities, as the American Bureau of Shipping, and then kept. Plans should show placing of welds where location is important. Essentially, the drawing room should take control of the quantity of welding. With this responsibility goes the demand for exact detailed and thorough welding knowledge on the part of the designers.

Beyond even this, the plans should show assembly groups—their weights calculated to be sure of crane capacity, and their design and erection method arranged to allow for or compensate the predicted distortion or shrinkage. Storage of finished assemblies should be planned and fabrication and erection sequences studied. If those things are not worked out in advance, delays, bottlenecks in production, waste and inefficient use of facilities will result. So you see it isn't just a matter of leaving off the connecting angles and hoping the yard can work it out.

Of course, material ordering is tied in with plans, but it has its own problems. With punching eliminated, plate width is no longer controlled by punch gap. Generally speaking, the larger the plate that can be used, the greater the economy. The larger plate reduces welding, and in spite of all our advance in welding technique, the cheapest weld is still the one you don't do. Base prices on steel go to 100 inches in width and except in special cases, it seldom pays to exceed this width if only to avoid a welded seam. Welding offers the chance to order steel neat to size as mill variations can be absorbed in an assembly, as the exact location of intermediate seams or butts within the body of an assembly is not a matter of great moment. Here again, design enters, the layout should be such as to permit of some come-and-go on terminations and connections, brackets should cut without waste.

LAYING OUT THE WORK

Our plans are finished—we go into the loft. Here a substantial saving is made. The templets are simpler, fewer in number, and in many cases are vanishing entirely. For barge work, or straight repetitive midsection fabrication, templets can be replaced by jigs and fixtures. For example, Bethlehem is using a welded inner bottom design where all floors are solid plate burned out for access holes, limber and air holes, joggles for seams and cut for deadrise and bilge curve. These floors are cut two at a time on automatic duplex burning machines having beds 16 feet wide and 96 feet long. The plates are dropped into alignment jigs and cut from one master templet which is essentially a portion of fashioned scrieve board.

There is no layout operation and one templet serves for all floors of a type. The floors finish exactly and are ready for assembly at once. As a result, floors are costing 40% of what was formerly considered good performance on the same design of floor burned by hand and laid out by usual shipyard methods.

Side frames are handled in a similar manner by another machine which cuts shape, joggles, drainholes, etc. at one operation. In barge work, it is perfectly possible to eliminate loft work entirely, by use of jigs and stops.

The templets, where necessary are vastly simpler, there are no rivet holes and generally the templets show only fabricating operations. There are two schools of thought on the question of marking welding on templets.

One group feels that the loft possesses greater ability to read plans, etc., and can work out welding to better advantage. Our present practice at Fore River, however, is to avoid layout of welding on templets. Many parts which would otherwise need no templet would require one to mark up welding only. Repeated use of the templet would obscure markings and require better and renewed templets. Accordingly, parts are assembled and a special man or group capable of reading plans and possessed of enough intelligence and welding knowledge lays out the welding directly on the steel. In our opinion, this practice is preferable, although it is conceded that many yards are very successfully doing just the opposite with good reason.

THE SHOP AND YARD

When we get into the structural steel shop we again find great simplifications possible. Although in the old line shipyards where riveted ships have been built for years punches and planers and all the other tools incident to riveting still remain to a great extent, the tendency in all the new yards and the "rejuvinated" yards is to provide only flanging and bracket shearing machinery, but to "go heavy" on mechanical burning and welding equipment. Even the furnacing equipment is being reduced—and a lot of shaping is being done by local heating with torches rather than in the furnace. As welding becomes more and more firmly established, it is inevitable that rearrangement of the present shipyard shops will have to be made.

A *riveted* structure has about 70% of the total fabricating man hours spent in machine work before fastening parts together—

A *welded* structure uses only 30% of the total fabricating time prior to welding. This is a basic difference and is bound to cause extensive changes in shop layout if we are going to get the most out of our available shop space.

In the barge field, this change has already happened. The Bethlehem Steel Co. plant at Leetsdale, Pennsylvania, has been rearranged and major changes of tooling and material handling, including barge transfer equipment have been made. Our 27th Street yard in Brooklyn is arranged for straight line production of barges with transfer equipment for entire barges. For a complete account of the major transformation in shop arrangement at the Dravo Corporation, it is interesting to study a paper by Mr. George Wolfe and Mr. Paul Strohl read before the Pittsburgh chapter of this society and published in the February issue of our Journal. There are

two views on yard equipment. And actually both are in a large measure correct. The small yard with intermittent periods of work and total shutdown must economize on fixed charges and investment.

The large yard must have facilities in keeping with the work it must do. The equipment that would fall short of being bare necessity in one case would mean an investment that would swamp the small builder. Yard equipment, generally, increases the speed and physical ease of doing the work. This means lesser labor costs on any given job. But, it also means expense and investment and if the resulting fixed charges are properly allocated—may—especially where quantity of work is not great or continuous in nature—actually result in increased over-all cost.

Cranes and handling equipment are the primary need. Basically, of course, the downhand weld is easier and cheaper to do, and so far, all automatic welding must be done in this position. From this standpoint it becomes desirable to position the work as much as possible and to make up assemblies as large as possible to avoid vertical and overhead welding. But cranes cost money, increasing rapidly in cost with increase in capacity. If then, for example, the only reason for a fifty-ton crane is to make a joint between two 25-ton assemblies in the downhand position possible, we should remember that vertical welding is perfectly possible and practical and that a relatively small saving on one welder's time does not go very far toward paying for increasing a crane from 25- to 50-ton capacity. If there are only a few such lifts, the answer is obvious. Fifteen- to twenty-ton cranes, arranged where possible to work in pairs, seem to be the economic answer, although some yards favor somewhat larger units.

Storage space is very important and sometimes almost impossible to obtain in going shipyards. Crane service over storage areas of course is imperative. By storing assemblies it is possible to achieve planned repetitive production of duplicate parts and to increase the amount of pre-fabrication. This, in turn, helps to reduce time on ways and may relieve congestion in a yard where the number of ways is limited. But, property and craneways cost money and that cost must be balanced against the value of time in delivery.

Enclosed or sheltered assembly space is a great advantage—welders are much more sensitive to wet than riveters. A shower will delay a gang of riveters as long as it is raining hard, but the welders will have to wait until things dry up to a great extent. Under shelter, the welders will do better and cheaper work and turn it out with lesser delays. But, and there is always a *But*, buildings cost money and where the climate is favorable the real gain in production may again not justify the investment.

These items of cranes, storage yards and shelter are in a sense additions to present essential shipyards services and the pro and con of their use is brought out to show the importance of careful study of their economics before concluding that a vast rebuilding is necessary to utilize welding.

AUTOMATIC WELDING

There is another phenomenon brought about by welding upon which there is a great and justified diversity of opinion. That is the question of work flow—should the work be brought to the welding equipment or should the welding equipment go to the work. This is particularly pertinent when considering automatic welding.

Automatic welding of all types is more weather-sensitive than hand welding and until very recently some types of machine welding could not be satisfactorily performed out of doors. Bringing the assemblies to the welding machine which is housed in a heated building with proper cranes and assembly jigs, clamps and fixtures has great advantages in perfecting the weld itself and in reducing the cost of the actual weld. The very excellent layout of the Sun Shipbuilding Company which was inspected by the Society of Naval Architects several years ago is perhaps the outstanding example of the development of this principle of flow. It is evident, of course, that the economic principles of crane equipment storage areas and shelter combine to affect the over-all costs achieved by bringing work to the welder. If there is sufficient quantity of similar work unquestionably operating economies result.

All recent development of automatic welding, however, has been in the direction of improving its weather worthiness, ruggedness and portability. Costs of equipment have also been reduced, so that it is becoming more and more practical to cheaply bring the welder to the work. In established yards where space is at a premium and shops cannot be drastically pre-empted and altered the most practical thing seems to be to work on this principle. Welding costs per foot will be greater but with a wide variety of work the over-all cost will probably be less. One tendency of a fixed set-up is to freeze designs into one standard method of construction, and ships just don't grow that way.

In general talk on the business phase of shipbuilding it is not desirable to go into the technical side of welding with its many ramifications into stress analysis, metallurgy, etc., all of which have been and are being discussed in detail in the AMERICAN WELDING SOCIETY'S JOURNAL every month. From the money-making standpoint, however, the introduction of automatic welding presents many problems and its advantages and limitations definitely affect costs. Let us, therefore, compare some of the basic characteristics of hand welding and some of the several methods of automatic welding.

Today, hand welding is beyond the experimental stage; the present trend is, in this country, toward larger wire and heavier currents with greater stress being laid on penetration and less accent being placed on the quantity of "applied" metal. Our welders can weld expertly in any position, and trained men are available, not in entirely sufficient quantity perhaps, but definitely more plentifully than in Germany, for example, where they are still riveting the upper boundary bar of bulkheads (to quote) "release the skilled men for more important work."

In the various Bethlehem plants nearly every type of automatic welder has found a use. In our Leetsdale plant, where the river barge building activity is centered, the carbon arc is extensively used. In this plant, also, large quantities of large diameter special pipe are produced. For this purpose, a large plate edge upsetting machine has been developed. This machine upsets the two edges of a plate and provides the necessary excess metal for fusing with the carbon arc to make excellent butt joints.

At our 27th Street plant in Brooklyn, we have used the carbon arc without metal addition using lap joints. We have also developed an automatic intermittent welder which is used to attach "I" beam stiffeners to shell and bulkhead plating.

Our Staten Island plant is now using this type of stiffener welding on the C-1 vessels building for the Maritime Commission.

The carbon arc has the advantage of low material costs and simplicity particularly when no metal is added. The

deficiency of metal at the joint which must be supplied from the parent metal being joined limits the design of joints to overlaps. With added metal filler rod, of course, butts can be made and extensive experimental work is now under way to make a practical application of this type of weld to large shipbuilding. At the present time, however, the practical upper limit of plate thickness for unfilled carbon arc weld is about $^{7}/_{16}$ inch in the flat position.

The bare wire welder is being used in our Sparrows Point Maryland Plant to build up pistons and cylinders of the many large gas engines which are used for making power and compressing air in the steel mills. These welders are mounted on lathes and the work rotated under them. The quantity of weld metal deposited is sufficiently good for this purpose but it is doubted if it would be acceptable in ship work.

Three of our shipyards are using the Unionmelt, or submerged arc wire welder. We have three such machines in operation in our San Francisco plant welding inner bottoms, bulkheads and decks. One similar machine is in operation at Staten Island. At Fore River, we are welding gun turrets and other naval work.

From the economic standpoint, there are many factors to be considered. Any automatic weld is essentially a high speed heavy current operation, making a large puddle of molten metal. This at present at least, limits it to down welding. The extent to which it can be used goes back to assembly design, and crane capacity with their attendant economic limits.

The automatic machine takes more space than a man welding by hand and access must be provided with clearance for the machine. It takes time to bring the machine to the weld and to set it up—there must therefore be sufficient straight run available to make it worth while to set up.

Lastly, the material cost per pound of weld may be very much greater than the rod cost of hand welding. A consensus at the present is that the lower limit of thickness for economic application of automatic protected wire welding, in shipbuilding at least, is about $^{5}/_{8}$ inch. The process attains its greatest value in the thicker plates where it has no competition.

Against all these factors we have the tremendous advantage of greater welding speed, better quality welds, and far less distortion to contend with. These things go far to overbalance the difficulties, but in themselves are not enough to make automatic welding a royal road to riches.

Any automatic process can show welding speeds under proper conditions which make hand welding look like the horse and buggy age. Carbon arc speeds, for example, on $^{5}/_{16}$-inch plate run 90 to 120 feet per hour—wire welding can be done at 150 to 175 feet per hour or better. These speeds, though, are while you are welding.

If we set up an equation where the speed of welding, say 90 feet per hour is multiplied by a coefficient to equal the actual quotient of net applied footage, divided by total man hours labor we find that such a coefficient of application will run about 25 to 35% in a good installation. Thus, a welding of 90 feet per hour reduces to say 30 feet per charged man hour. This coefficient of application is the shipyards job, and it amounts to $^{2}/_{3}$ of the success of the application.

To increase this factor is beyond the power of the welding machine maker. It involves design, crane equipment, production study, scheduling and many other factors of shipyard operation. All this is the shipbuilders' responsibility, and let us add—is a neat problem.

To help the shipyard solve this problem, the welding machine manufacturers are lending considerable technical aid and are making great improvements in increasing the portability, ruggedness, flexibility, and weather-worthiness of their machines.

WELDING PROBLEMS

We have spoken of the many advantages of welding, but there are also many problems not present in riveted work. Of these, perhaps, the most annoying and costly is warpage and shrinkage. The AMERICAN WELDING SOCIETY has had a very able committee working for several years on the problem of thermal stresses and I have seen the preliminary copy of their report. It is my understanding that it will shortly be published in the Journal and I heartily advise its careful study by our Naval Architect friends. The subject is a highly technical one and much effort has been put on its solution. As yet, however we know of no general method of design or procedure that will absolutely assure a warpage and stress-free structure every time.

Practically all of the other departments in the shipyard such as pipe shop, outfitting, rigging, electrical and even the joiner departments are using welding in increasing amounts. The effort in all cases is to cut costs—but in none of these cases is the fundamental principle of the structural design of the ship radically altered.

One major effect of welding that is being felt more and more is in the selection, training and management of the shipyard labor. Welding does not require the same type of physique that was associated with the riveter. Welders may be made more easily and the work appeals to a greater group of young men.

REPAIR WORK

Well, we have our ship—our owner has accepted her and she has sailed away from the building yard. But Bethlehem's interest in the vessel, however, is not at an end. Repair yards up and down both coasts still have a potential customer in our ship. As more and more welded ships dot the seas the "repair game" is being increasingly affected.

There have been numerous arguments on repair costs of welded ships. Repair men cite the comparative ease of removing a plate from a riveted ship and point to the apparently high costs of repairing welded work on a damage of equal extent. Of course, no two damages are identical, but I believe in making even argumentative comparisons another basis should be used. Let us not compare damages of equal extent—as for example the cost of removing a plate—but rather think along the line of comparing the bump or the impact. Thus, a welded ship has received a bump or bumps which finally result in a damage which requires repair at a certain cost.

What would an equivalent set of bumps have done to a riveted ship?

You will find that in many cases the superior ability of the welded structure to absorb damages without leakage, and the stiffer and more intimate connection of parts will reduce the extent of damage and may in many cases permit of deferring the repair until a convenient time in the owner's schedule. If two or more minor damages can be repaired by bringing the ship into the yard only once, the saving to the owner in lost time, etc., will be greater than the repair cost.

A New Method of Welding Galvanized Sheets

By A. R. ECKBERG*

THE Eastman Kodak Company has been a large industrial user of air conditioning for many years. Quality control of photographic film and paper has necessitated exact temperature and humidity conditions in nearly all of the important manufacturing departments. Hence, we have been building and installing large air ducts, air washers and other conditioning equipment of galvanized iron sheets for a long time. The conventional method of joining galvanized sheets by riveting and then soldering for an air tight joint, does not provide a strong joint; the flux used for the solder often causes zinc oxide formation in moist atmospheres, and finally it is quite expensive in the construction of large sized equipment.

For these reasons, early in 1935, the Company started searching for an improved method for joining galvanized iron sheets. We finally developed a method of carbon arc welding with a filler rod of copper silicon alloy such as are commercially available in "Ever-dur, Herculoy, Olympic bronze, etc."

We found, however, that there was a margin along the weld line from which the zinc coating was removed by volatilization during the heating of the weld and that this zone was in effect an unprotected area of bare iron which was extremely susceptible to rusting in air conditioning equipment or air ducts.

Further development of this process by Mr. T. S. Gaylord of our Metal Shop resulted in our coating the copper alloy rod with block tin. We now found that the block tin deposited itself adjacent to the weld metal, and if proper procedure was used, the bare iron was fully covered over with molten tin at the same time the weld was deposited by the carbon arc.

*Asst. Superintendent, Engineering and Maintenance Dept., Eastman Kodak Co., Rochester, N. Y.

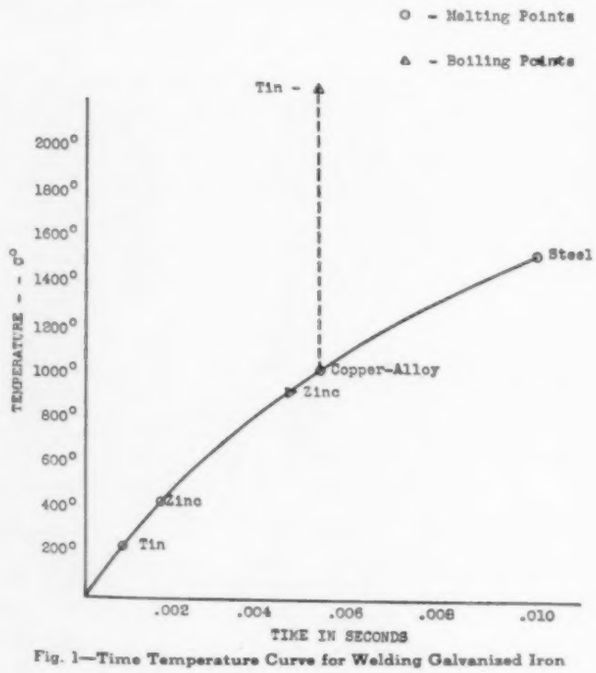


Fig. 1—Time Temperature Curve for Welding Galvanized Iron

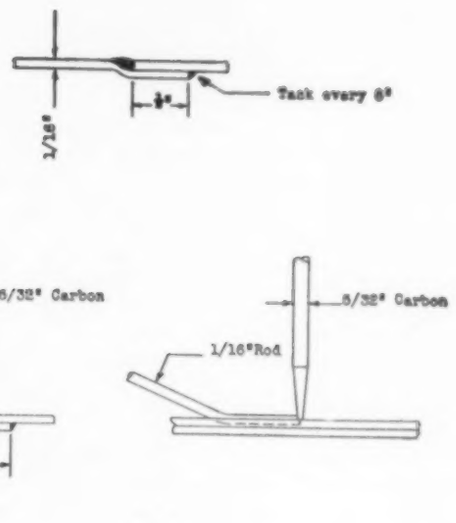


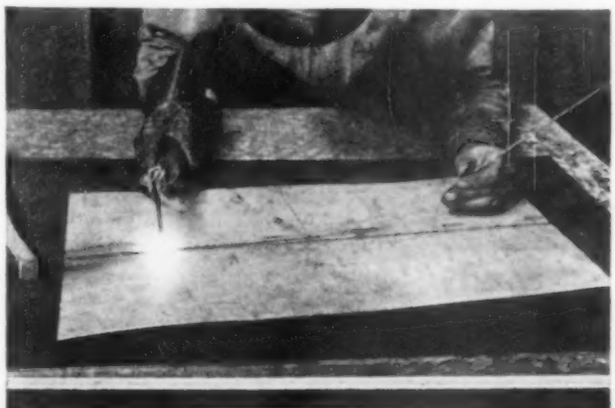
Fig. 2

The adequacy of this protection was checked by the "Preece" test method, and it was found that welded joints of this description would withstand a two or three dip tests in the copper sulphate solution.

The process briefly described above, that is, the carbon arc method with copper alloy, tin coated welding rod has now been effectively covered by the Gaylord patent #2,170,019, dated August 22, 1939. A detailed explanation of what occurs in this process is as follows:

In the Gaylord welding procedure, the tip of the carbon is held approximately $^2/_3$ of the way through the copper alloy rod which is laid flat in the fillet of the seam. The chart shown in Fig. 1, indicates that the melting point

Fig. 3—The Gaylord Process of Welded Galvanized Sheets—Depositing Weld Metal in Fillet of Jog—Lap Joint



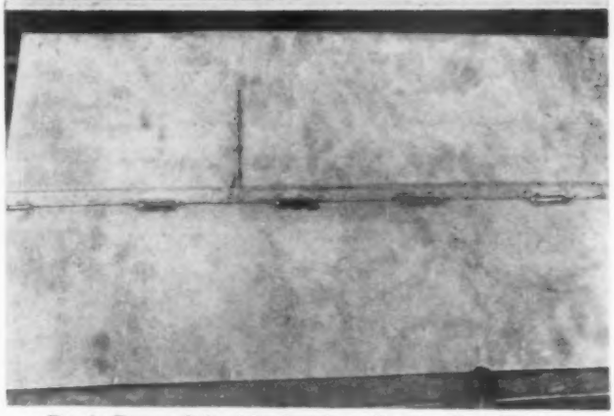


Fig. 4—Reverse Side of Jog Lap Joint Showing Tack Welding

of the tin coating is 231° C., while its boiling or volatilization point is 2260° C. The melting point of zinc is 419° C. with a boiling point of 907° C. The melting point of the copper alloy rod (96% Cu, 2½% Si, 1½% Mn) is 1020° C. As the heat of the carbon arc is applied, the tin goes into a liquid form at 231° C., the zinc passes into a liquid form at 419° C. but volatilizes at 907° C. which is 113° C. below the melting point of the copper alloy rod. This then is the reason that the zinc coating is driven off adjacent to the welded seam. The tin coating, however, does not volatilize at all, but remains in a liquid form since the copper alloy rod melts at 1020° C. or 1240° C. below the boiling point of tin. The carbon tip is then moved along at the approximate rate of 1 inch for 5 seconds, so that a new portion of the coated rod is brought into contact with the heat of the carbon arc. A microscopic examination of the protective coating which replaces the volatilized zinc coating adjacent to the weld, discloses that it seems to be made of successive longitudinal layers of pure tin coating with finally an alloy of tin and zinc with the zinc content increasing as we move away from the weld proper. The total width of this entire area, however, if the above procedure is correctly followed, will only be from $^1/_{32}$ inch to $^1/_8$ inch on each side of the weld on 16-gage galvanized sheets.

Experiments were made to determine the best type of joint for the Gaylord process. We tried out several, from the plain butt joint to a straight lap joint and finally settled on an offset lap joint as offering the best condition for this process. The offset lap joint gives us an opportunity for laying the filler rod in a fillet as shown in Fig. 2. The bottom portion of the lap joint also helps to remove the heat of welding current so that there is little or no damage to the galvanizing on the side of the sheet opposite to the weld. Numerous tests have been made in a Riehle pull test machine which indicated that this type of joint developed approximately 90% of the strength of the galvanized sheet, with an average ultimate tensile strength of 51,000 psi.

It will be seen that this method of joining galvanized sheets has made possible important changes in the design of galvanized iron equipment. For example, the fact that we now have a joint with a strength of 51,000 psi makes it possible for the air conditioning engineer to figure on fewer hangers and a consequent saving in installation costs. This same strength enables us to build our air ducts and other air conditioning equipment of a size to allow for frequent cleaning by actually sending men through long runs of air ducts thereby improving considerably the quality of our products.

The accompanying illlustrations indicate the types of equipment which we now build using the Gaylord process.

The experience of our Company indicates that in addition to providing a joint which is very much stronger, and that is fully corrosion resistant to damp atmospheres, the use of the Gaylord process also results in lowered cost on the high grade type of air conditioning equipment and air ducts which we build and install in our various plants.

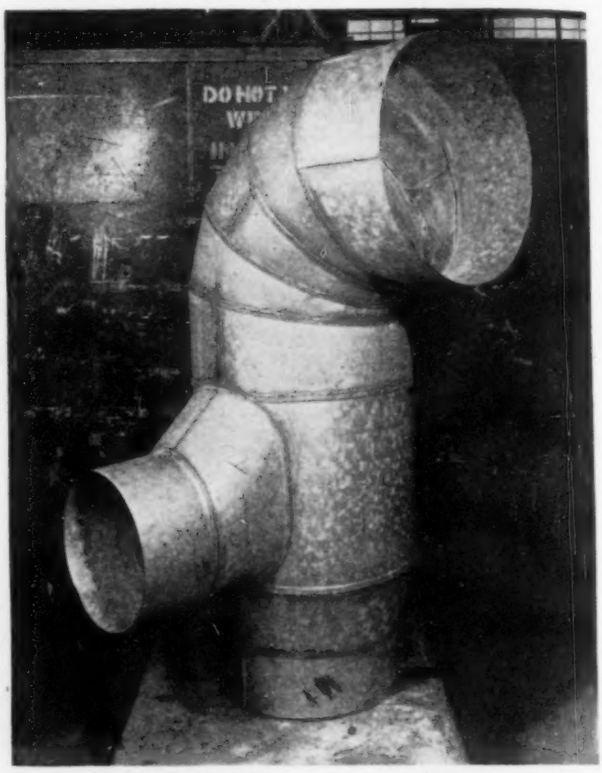


Fig. 5—Special Offset Elbows for Air Ducts

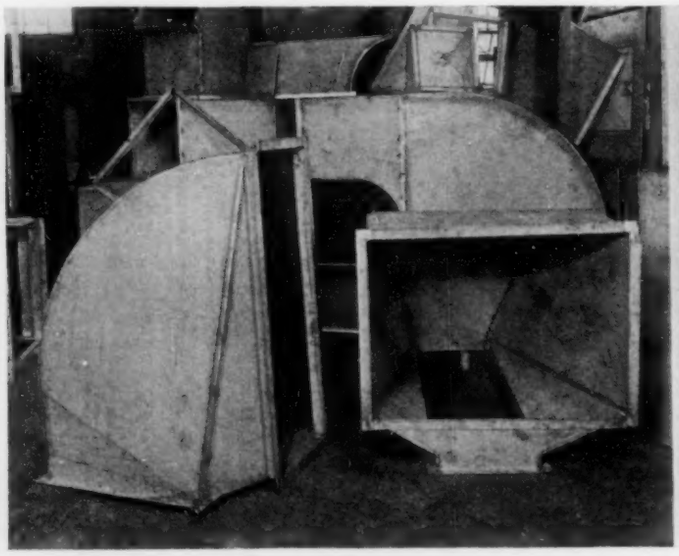


Fig. 6—Air Duct Connections

Fig. 7—Laboratory Equipment—Galvanized Sheets Welded Construction

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Welding Society ACTIVITIES — Related Events

EXECUTIVE COMMITTEE MEETING FEBRUARY 29th

Annual Meeting Report

Mr. McCune as Treasurer of the Society and Chairman of the Convention Committee presented a comprehensive financial report giving the results of the operations of the Annual Meeting. Mr. McCune stated that the 1939 Annual Meeting Cost was $900.00 more than the Annual Meeting Income—spent mostly on (1) Technical Sessions, and (2) on publicizing the Meeting and Exposition.

The Executive Committee unanimously voted to express its thanks to the Chicago Section members for their splendid cooperation and endeavors in making for the success of the Annual Meeting. A similar vote of thanks was expressed to the Convention Committee.

Meetings and Papers Committee Recommendation

The Meetings and Papers Committee recommended that the Executive Committee officially designate November 1st of each year as the closing date for inclusion of names in the new Year Book. The request was granted.

Welding Handbook

The Executive Committee voted to authorize the appointment of a Committee consisting of Messrs. C. A. Adams, H. C. Boardman, W. F. Hess, C. W. Obert and W. Spraragen, Editor, to constitute a Handbook Committee for the preparation of a second edition of the Welding Handbook to be issued sometime in 1941.

Outline of Work Recommendations

The following new appointments were made.

Mr. A. K. Seemann of the Union Carbide Company, to serve on Committee on Minimum Requirements of Instructions for Welding Operators in Trade Schools.

Dr. A. G. Granch, 30 East 42nd Street, New York, N. Y., to serve on the A. S. A. Committee Z37 "Allowable Concentration of Toxic Dusts and Gases," as the A. W. S. representative.

The Filler Metal Specifications were approved for publication as a general specification of the A. S. T. M. and the A. W. S.

The Standard Qualification Procedure was approved but publication was delayed until the completion of a table relating to grouping of materials according to weldability.

ANNOUNCING NOMINEES FOR OFFICE OF DISTRICT VICE-PRESIDENTS FOR YEAR 1940–1941

In accordance with By-Laws, Article V, Section 6, there is published below list of candidates nominated by the various District Nominating Committees for the office of District Vice-President.

Middle Eastern District—Edward T. Scott, President, Cleveland School of Welding, Cleveland, Ohio.

Southern District—Mr. O. T. Barnett, Metallurgist, Black, Sivalls & Bryson, Inc., Box 1377, Oklahoma City, Oklahoma.

Middle Western District—Mr. D. H. Corey, Welding Engineer, The Detroit Edison Co., 2000 Second Ave., Detroit, Michigan.

New York-New England District—Mr. P. J. Horgan, Engineer, General Electric Company, Lynn, Mass.

Pacific Coast—Mr. L. W. Delhi, Manager, Western Pipe & Steel Co., 444 Market Street, San Francisco, Calif.

You are reminded independent nominations may be made by petition of 25 or more members, sent to the National Secretary, not later than May 15th. Such petition for the nomination of District Vice-President must be signed only by members within the District concerned.

The national ballot for nominations of officers will include the names of the District Vice-Presidents nominated by the District Nominating Committees, and the names of nominees nominated by petition. Only District members will be eligible to vote for District Vice-President.

NORTHERN NEW JERSEY SECTION ORGANIZED

The Northern New Jersey Section was launched on the evening of March 14th.

The organizational meeting was held at 7:30 P.M. in the Auditorium of the Public Service Terminal Building, Newark, New Jersey. Mr. H. S. Card acted as Temporary Chairman, Secretary and Treasurer. He briefly reviewed the events which led up to the formation of the Northern New Jersey Section. He pointed out the need for a local Section of the AMERICAN WELDING SOCIETY in this district, constituting as it does, one of the greatest industrial centers in the country.

The technical paper was presented by Mr. K. W. Couse, of the Couse Laboratories, Inc., on the subject of Building a Mobile Airport. Mr. Couse's talk presented some recent and extremely interesting developments in rendering first aid to aviation, and described outstanding examples of welded construction for extra heavy duty. It was illustrated by lantern slides and motion pictures.

Mr. Couse answered numerous questions in connection with the construction and operation of the Mobile Airport.

Following the technical sessions, Mr. Card introduced Professor W. F. Hess of Rensselaer Polytechnic Institute, who is also Divisional Vice-President of the New York & New England Division. Professor Hess briefly traced the growth of the Society, its importance to the welding industry, the service it has rendered American industry in general and the opportunities which exist through affiliation and cooperation with the Society. He was followed by Mr. W. Spraragen, Technical Secretary and Editor of the Journal. Mr. Spraragen pointed out the success of any Section or the national Society itself is dependent on the cooperation of its individual members. Mr. Spraragen then outlined the technical work of the Society and the research activities.

The nominees selected by the Nominating Committee were unanimously elected. They are as follows:

Chairman—F. C. Fyke, Standard Oil Development Co.

Vice-Chairman—P. A. Salmon, Public Service Electric & Gas Co.

Secretary-Treasurer—H. S. Card, 449 Elmora Ave., Elizabeth, N. J.

Executive Committee—Willard Emery, Worthington Pump & Machy. Corp.; R. E. Powell, Western Electric Co.; G. C. Holder, Foster Wheeler Corp.; G. W. Nigh, Tidewater Associated Oil Co.; G. J. Blind, Midwest Piping & Supply Co.; E. F. Humm, Chicago Bridge & Iron Co. and Henry Troger, Federal Shipbuilding & Dry Dock Co.

The meeting was then turned over to Mr. Fyke who pointed out the opportunities and possibilities of the newly organized Section. He invited every member to participate in this work. In spite of the inclement weather there were 225 people present.

Mr. Fyke announced that the next meeting would be held April 16th, 7:30 P.M., in the Oxford Room of Hotel Essex, Newark. The speakers will be Harry E. Rockefeller, Manager, Process Development Dept., The Linde Air Products Co., on "Plate Edge Preparation for Welding," and Harry W. Pierce, Supervisor of Welding, New York Shipbuilding Corporation, on "Gas Machine Cutting in Shipbuilding."

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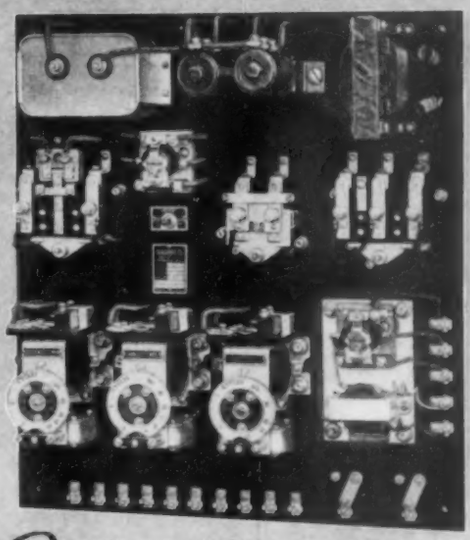

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3. When the weld is completed, it determines the period during which the electrodes maintain pressure after the current is cut off.
4. It controls the period when the electrodes are open before the operating cycle is repeated.

For electronic equipment, a protective relay is necessary. This relay is energized from the load side of the power tubes and is specially designed to operate under a wide variation in voltage. This interlocking system prevents the electrodes from opening while any current passes through the electrodes. It also permits independent adjustment of the weld time without changing the other sequence intervals.

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A. I. E. E. VICE-PRESIDENT

Klaus Lobeck Hansen consulting engineer, Harnischfeger Corporation, Milwaukee, Wis., has been nominated to serve the Institute as vice-president representing the Great Lakes District (number 5). He was born in Sandefjord, Norway, September 14, 1882, and came to the United States in 1901. He was employed by the National Stamping Works and the Western Electric Company, both at Chicago, Ill., before entering the University of Illinois where he studied electrical engineering 1903–05. After several months with the Chicago Edison Company, he was employed by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., in 1906 and continued with the company until 1919, his last position being designing engineer on D.C. apparatus. In 1919 he went with the Mechanical Appliance Company (later the Louis Allis Company), Milwaukee, as designing engineer, later becoming chief engineer. He left the company in 1921 to engage in consulting and development work on his own patents. He invented the Hansen arc welder, and in its manufacture and sale was associated with the Northwestern Manufacturing Company, Milwaukee, from 1924 to 1932, when it was taken over by the Harnischfeger Corporation. He holds patents on various arc-welding processes and joint patents on induction motors, and has published a number of technical papers, chiefly concerned with welding. He has been a member of the Institute's electric welding committee 1930 to date (chairman 1932–34), was chairman of the Milwaukee Section 1933–34, and chairman of the 1937 A. I. E. E. summer convention committee. He is also a member of the AMERICAN WELDING SOCIETY, at present serving as vice-president representing its Middle Western Section.

Klaus Lobeck Hansen

A. W. S. LECTURE SERIES

The Metallography of Welding

In response to numerous requests, the Northern New York Section of the AMERICAN WELDING SOCIETY has arranged a series of four lectures on the fundamentals of The Metallography of Welding. This series started Wednesday, March 13th at 8:00 P.M. sharp. All meetings were held at the General Electric Co., Building No. 32 (On Erie Blvd.) Schenectady.

An outline of the series follows:

March 13th—I. The Structure of Pure Metals
March 20th—II. The Structure of Alloys
March 27th—III. The Effects of Heat
April 3rd—IV. Study of the Process of Welding

This series was intended to provide the essential background for additional courses which are being planned for the future and which will cover in more detail the various phases of welding. It was designed to be of interest to all who are connected with welding from the designing engineer to the welding operator.

These lectures were presented by L. L. Wyman, Metallurgist in the Research Laboratory, General Electric Co.

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WELDING—EDUCATIONAL LECTURE COURSE

Following inquiries from structural engineers engaged in design work in various Government agencies, the Washington Section of the AMERICAN WELDING SOCIETY planned an educational lecture course covering the fundamentals of welding as applied to structural design. These lectures were planned in addition to a series of seven lectures scheduled for the regular meeting nights of the Section. The schedule of the educational lectures follows:

Lecture One—January 30, 1940. Introduction to Lecture Course by Rear Admiral Ben Moreell (CEC), USN, Chief of the Bureau of Yards and Docks. Welding Processes. Speaker: Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Company.

Lecture Two—February 8, 1940. Types of Welded Joint, Working Values and Application. Speaker: Mr. C. H. Jennings, Research Engineer, Westinghouse Electric and Manufacturing Company.

Lecture Three—February 15, 1940. Welding as Applied to Building Construction. Speaker: Mr. A. N. Kugler, Structural Engineer, Air Reduction Sales Company.

Lecture Four—March 7, 1940. Welding as Applied to Bridges and Rigid Frames. Speaker: Prof. C. D. Jensen, Lehigh University, Bethlehem, Pennsylvania.

Lecture Five—March 14, 1940. Welding of Floating Equipment and Derricks. Speaker: Mr. George F. Wolfe, Welding Engineer, Dravo Corporation, Pittsburgh, Pennsylvania.

Lecture Six—March 21, 1940. Welding in the Design and Construction of Industrial Buildings. Speaker: Albert S. Low, Vice-President and Chief Engineer, The Austin Company.

Lecture Seven—April 4, 1940. Qualification of Welders and Inspection of Welds. Speaker: Mr. R. W. Clark, Research Engineer, General Electric Company.

Lecture Eight—April 11, 1940. Motion Picture—Making and Shaping of Steel.

The inaugural lecture of the course was held on January 30, 1940. Preceding the lecture, a dinner was given in the Queen Elizabeth Room of the Raleigh Hotel at which the honor guests, in addition to the speaker of the evening, Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Company, were:

Hon. Lewis Compton, Assistant Secretary of the Navy.

Rear Admiral Ben Moreell, (CEC), USN, Chief of the Bureau of Yards and Docks.

Rear Admiral A. H. Van Keuren, (CC), USN, Chief of the Bureau of Construction and Repair.

Commander L. B. Combs, (CEC), USN, Assistant Chief of the Bureau of Yards and Docks.

Colonel L. H. Tripp, Director of Construction Service, U. S. Veterans Administration.

Colonel John W. Oehmann, Inspector of Buildings, District of Columbia.

Mr. W. E. Reynolds, Commissioner of Public Buildings, Public Buildings Administration.

Dr. Lyman J. Briggs, Director, National Bureau of Standards.

Commander C. A. Trexel, (CEC), USN, Design Manager of the Bureau of Yards and Docks and Chairman of Educational Lecture Committee.

Mr. C. A. Loomis, Chairman of the Washington Section of the AMERICAN WELDING SOCIETY.

The lecture was held in the auditorium of the Department of Commerce at 8:00 P.M. Commander Trexel, in introducing Rear Admiral Moreell who made the introductory remarks, gave the following brief description as to the inception of this lecture course:

"As you all know, we are to have this evening the first of a series of seven lectures on structural welding. It might be of interest to you to hear briefly how this lecture course came into being.

"Two years ago, the Bureau of Yards and Docks took up welding in a serious way. Of course, the Bureau had been using welding for water-tightness and minor purposes for some time but for lack of suitable standards of design, inspection and qualification of welders, had not used it on important Bureau work involving the safety of human life. It was realized that standards were a prerequisite to adoption of welding for such work, and their preparation was accordingly undertaken. After compilation of available data and a great deal of research work and consultation with welding engineers of the country, two specifications, one for welding design and another for inspection, were completed and adopted for Bureau work, and have now for some time been in regular use.

"With the standards completed and available, it appeared that more training of the Bureau's structural design personnel, in welding, was the next step and a lecture course was suggested as a starter. The idea caught hold, somehow it got around to other Government departments, and in no time we were swamped with inquiries. At this stage, it was realized that the program had assumed proportions too large for a single Bureau undertaking and the Washington Section of the AMERICAN WELDING SOCIETY took it over.

"It has been a source of gratification that we were able to undertake the arduous and time-consuming task of preparing welding standards, and to adopt welding at a time when the Bureau was—and is—engaged in the heaviest peace-time construction program of its history. Notwithstanding this situation, the Chief of the Bureau, who of course has the responsibility of accomplishing this program not only approved, but actively fostered the adoption of welding on Bureau projects. Consequently, and not unnaturally, we feel that whatever results the Bureau has achieved in the promotion and adoption of welding, and indirectly in the organization of this lecture course, is due in no small part to him."

Rear Admiral Moreell, Chief of the Bureau of Yards and Docks, in introducing the lecture course, traced the rapid

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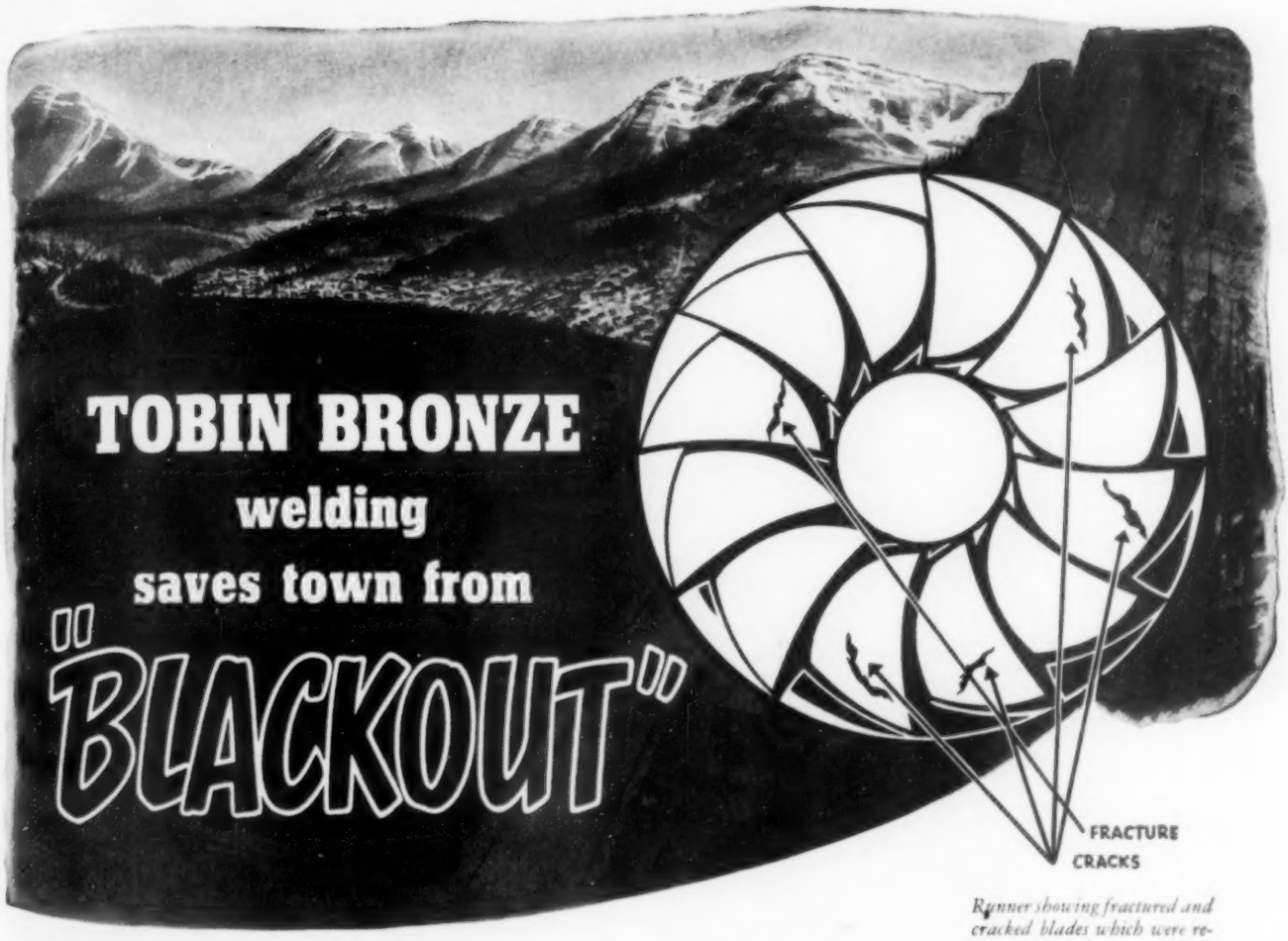

Runner showing fractured and cracked blades which were repaired in 6 hours by Tobin Bronze repair-welding.

Repair-welding of fractured blade in power plant turbine completed in 6 hours

A SERIOUS SITUATION developed in Banff, Alberta, not long ago. It was discovered that a blade in one of the two turbines of the local power plant was fractured. To make matters worse, closer examination revealed that four other blades were badly cracked. The turbine was useless. To dismantle and make the repair meant a delay of at least two to three weeks. To replace the turbine meant an outlay of about $1,200 and a delay of from three to four months. For a while, it appeared as though Banff were in for a "blackout." Then, repair-welding was suggested.

Through a 14″ manhole, Mr. Jackson of Jackson Welding Shop, Calgary, welded the fractured and cracked blades in just 6 hours—actual welding required only 2½ hours; preparation, 3½. Only 4 lbs. of Tobin Bronze welding rod were needed to avert what might have been a serious situation.

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growth of the Washington Section from its origin on October 2, 1937, with a membership of 35 and an average attendance at lectures of approximately 30, through its second year when the membership had increased to approximately 80 with an average attendance at lectures of about 70, up to the present membership of 122 with an average lecture attendance of over 200. Rear Admiral Moreell complimented the Washington Section in inaugurating this valuable lecture course and invited attention to the hearty response which has been shown by all departments. Rear Admiral Moreell cited examples of the prominence which welding is obtaining in the field of fabrication by enumerating some of the structures on which the Bureau of Yards and Docks has used welding recently, including five all-welded steel rigid frame buildings and two floating derricks. A great deal of the Bureau's railroad and hoisting equipment is welded at the present time.

Mr. Bibber, the principal speaker of the evening, dealt with the definitions and applications of the various welding processes. In his talk, he described the various processes thoroughly and impressed the audience that welding is a dependable tool of the fabricator and may be used without fear of failures. He traced the history of the development of welding and gave examples of the early difficulties which were encountered in obtaining satisfactory work. Following the general discussion, Mr. Bibber gave a demonstration in which he bent welded specimens that had been prepared by correct and incorrect methods, as well. During the demonstrations, he described the materials, methods used and the character of the specimen as shown by the break fracture or non-fracture.

In lecture number two, Mr. Jennings gave a brief review of the welding processes prior to a general discussion of the various types of joints and the allowable stresses used in those joints. He also gave some formulas for figuring the strength of the various types of weld joints. These formulas were based more or less on the information given in Mr. Jenning's paper which appeared in the Journal of the American Society of Mechanical Engineers during 1938, "The Stresses Set Up Through Dynamic Loading and Through the Use of Over-Reinforcement and Strap Welds." Mr. Jennings then showed slides which illustrated the different types of connections used in building, design and erection by the Westinghouse Electric and Manufacturing Company.

In lecture number three, "Welding as Applied to Building Construction," Mr. Kugler of the Air Reduction Sales Company, reviewed the processes and types of welds dealing to some extent with methods of calculating the strength of welds. Mr. Kugler discussed various types of joints used in a simple structure and methods of field connections such as the shelf angle, the more rigid type of connections known as the web connection and the connections on columns. Mr. Kugler showed a number of slides illustrating weld connections as used in buildings, designed and constructed in various sections of the country. It might be said that Mr. Kugler's talk was based to a great extent on "Weld Design" as edited by Mr. Gilbert Fish, Consulting Engineer.

Professor C. D. Jensen, in delivering lecture number four, "Welding as Applied to Bridges and Rigid Frames," discussed the fundamental advantages of welding as compared to riveting, followed by illustrations of several types of rigid frames as used in buildings and in bridges. Professor Jensen, in discussing the design of welded structures as compared with riveted structures, stressed the simplicity of a welded design through the minimization of the number of members used for making satisfactory connections. An explanation of the utilization of model analysis by designers of rigid frames was given in brief form with the close of his lecture dealing with erection problems which might be overcome through the proper design of shop and field joints.

The average attendance at these lectures has been approximately five hundred men. This attendance alone shows the interest of the structural engineers in the Washington area in the problem of welding as applied to the design and construction of buildings.

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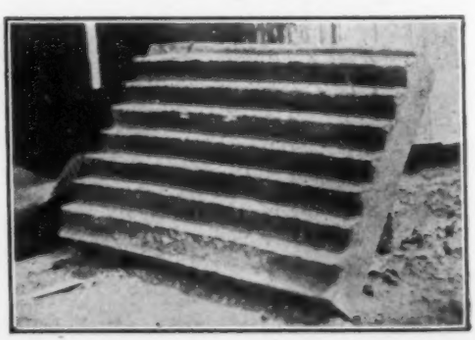

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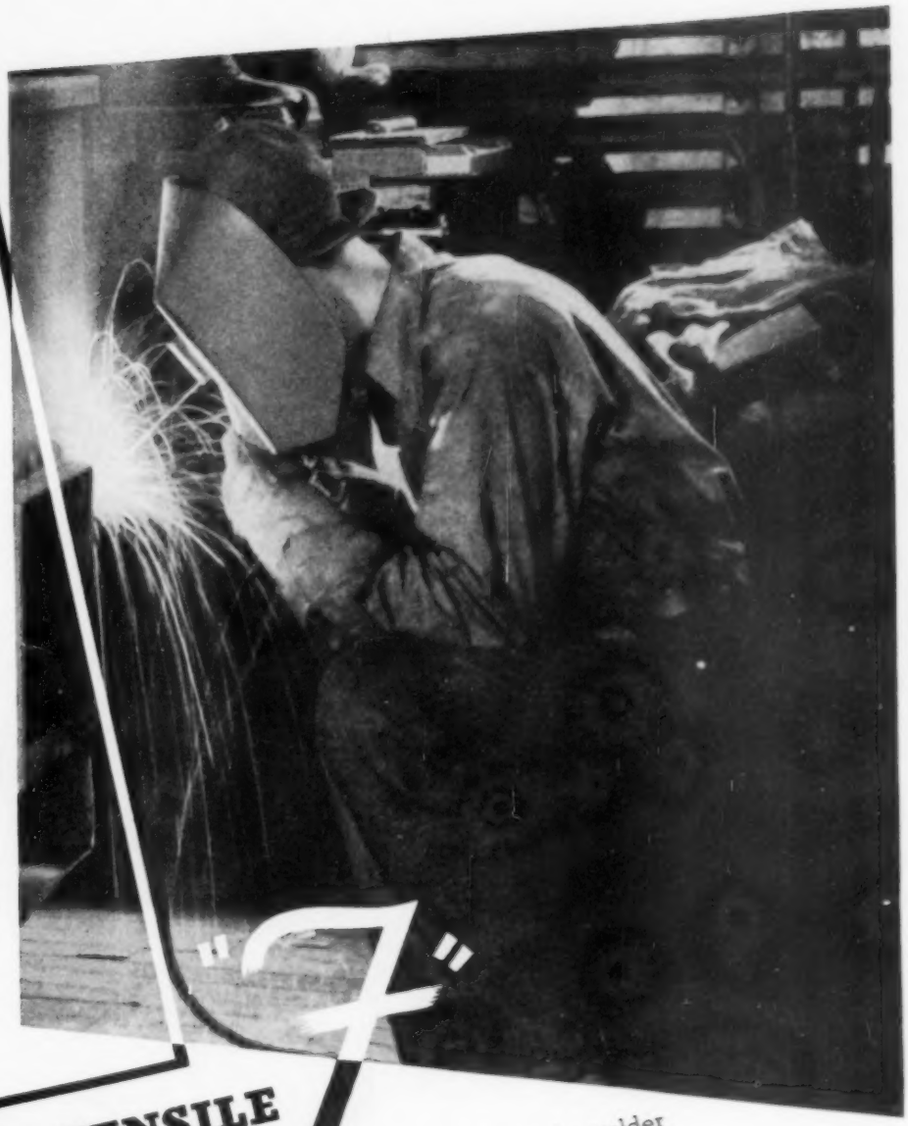

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TWELFTH WELDING CONFERENCE IOWA STATE COLLEGE, AMES MARCH 20, 21 and 22, 1940

Wednesday, March 20th

Registration, Engineering Exhibit Hall
Exhibits and Demonstrations, Exhibit Hall
Room 207, Engineering Hall
Chairman, Mr. R. H. Holbrook, Iowa State College
Recent Developments in Welding, by M. S. Hendricks, The Welding Engineer.
Cost Reduction and Efficient use of Materials, Illustrated by Celluloid Models and the Use of Polarized Light, by E. W. P. Smith, Lincoln Electric Company.
Flame Descaling, Cleaning and Dehydrating, by W. J. Carle, Air Reduction Sales Co.
Aluminum Fabricating Processes, Motion Pictures by U. S. Bureau of Mines.
Demonstrations, Exhibit Hall

Thursday, March 21st

Demonstrations, Exhibit Hall
Room 207, Engineering Hall
Chairman, L. O. Schneiderwind, Omaha Welding Co.
Welding Specialties and the Job Shop, by J. C. Menzies, C. E. Phillips & Co.
Boiler Welding, by C W. Zimmer, Hartford Steam Boiler, Insp. & Ins. Co.
Practical Discussion of Oxyacetylene Welding, by C. W. Ferris, Linde Air Products Co.
Fitting Farm Machines with Rubber Tires, by D. K. Struthers, Agr. Engr. Dept., I.S.C.
Welders Round Table—Oxyacetylene Welding, Discussion Leader—L. C. Monroe, The Welders Digest.
Demonstrations, Exhibit Hall
Welders Banquet, Direction W. L. Allan

Friday, March 22nd

Room 207, Engineering Hall
Chairman, W. L. Immer, General Electric Co.
Use of Liquified Petroleum Gases in Cutting, by H. A. Goodwin, Bastian-Blessing Co.
Control of Distortion from Welding, by W. R. Bernardi, Westinghouse Electric & Mfg. Co.
Resistance Welding and Controls, by R. W. Breckenridge, Mech. Engr. Dept., I.S.C.
Late Developments of the Metallizing Process, by L. E. Kunkler, Metallizing Co. of America.
Welders Round Table—Arc Welding Discussion Leader—Mr. L. C. Monroe
Demonstrations, Exhibit Hall

TRUCK AND PLATFORM CASTINGS ELIMINATED IN NEW PAULISTA LOCOMOTIVES

The four Paulista passenger locomotives recently shipped to Brazil are the first heavy main-line motive power units ever built without truck and platform castings, it was revealed by O. K. Kjolseth, of the General Electric transportation engineering department at Erie, Pa., who spoke (March 5) at a meeting of the transportation section of the Metropolitan (New York) section of the American Institute of Electrical Engineers. The built-up platform and the truck-frame structures are particularly notable mileposts in the rapid progress of the welding art, Mr. Kjolseth declared. Not only is the structure equal in rigidity to the cast frame, but there are less possibilities of defects and material savings in weight and cost.

Fabrication has been used extensively for a number of years in the construction of switching and small industrial locomotives in place of castings formerly used, but the Paulista electric locomotives, the largest direct-current locomotives ever built in this country, have set a record for advances in welding technique, the speaker emphasized.

The utilization of welding in the fabrication of large units such as truck frames, cab platform and cab structure gives not only rigidity, elimination of casting defects, and weight and cost savings, but also additional advantages in manufacturing flexibility which are of considerable importance. In the storage of parts, for instance, the keeping of such large units as truck frames or cab underframes offers a problem. Where a welded structure is used, however, the individual parts are relatively small and can be stored where space would not accommodate large finished parts such as frame castings. Welding also permits the building of subassemblies in any part of the factory, with the parts brought together later on the assembly floor for the final assembly into complete units. The finished nature of the structural material also permits the elimination of certain machine work and, in many cases where machining is necessary, it can be performed on the individual parts before they are assembled. This eliminates the necessity for moving large, heavy parts to be machined, as well as the requirement for special machines to handle such large units.

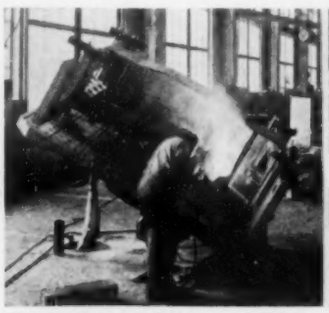

Fig. 1—Showing Rotary and Tilting Table in Use at Erie in Fabrication of Paulista Locomotives

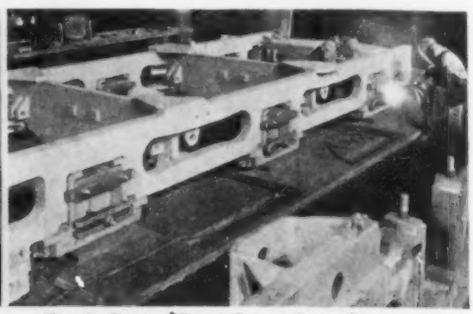

Fig. 2—Driving Truck Frame Being Fabricated

Welded Truck Frames

Successful fabrication of a structure such as the large driving truck frame of the Paulista locomotive calls for considerable skill on the part of the operators of the welding tools, Mr. Kjolseth said. To facilitate operations, the frame parts are first welded into several subassemblies, and these subassemblies then positioned

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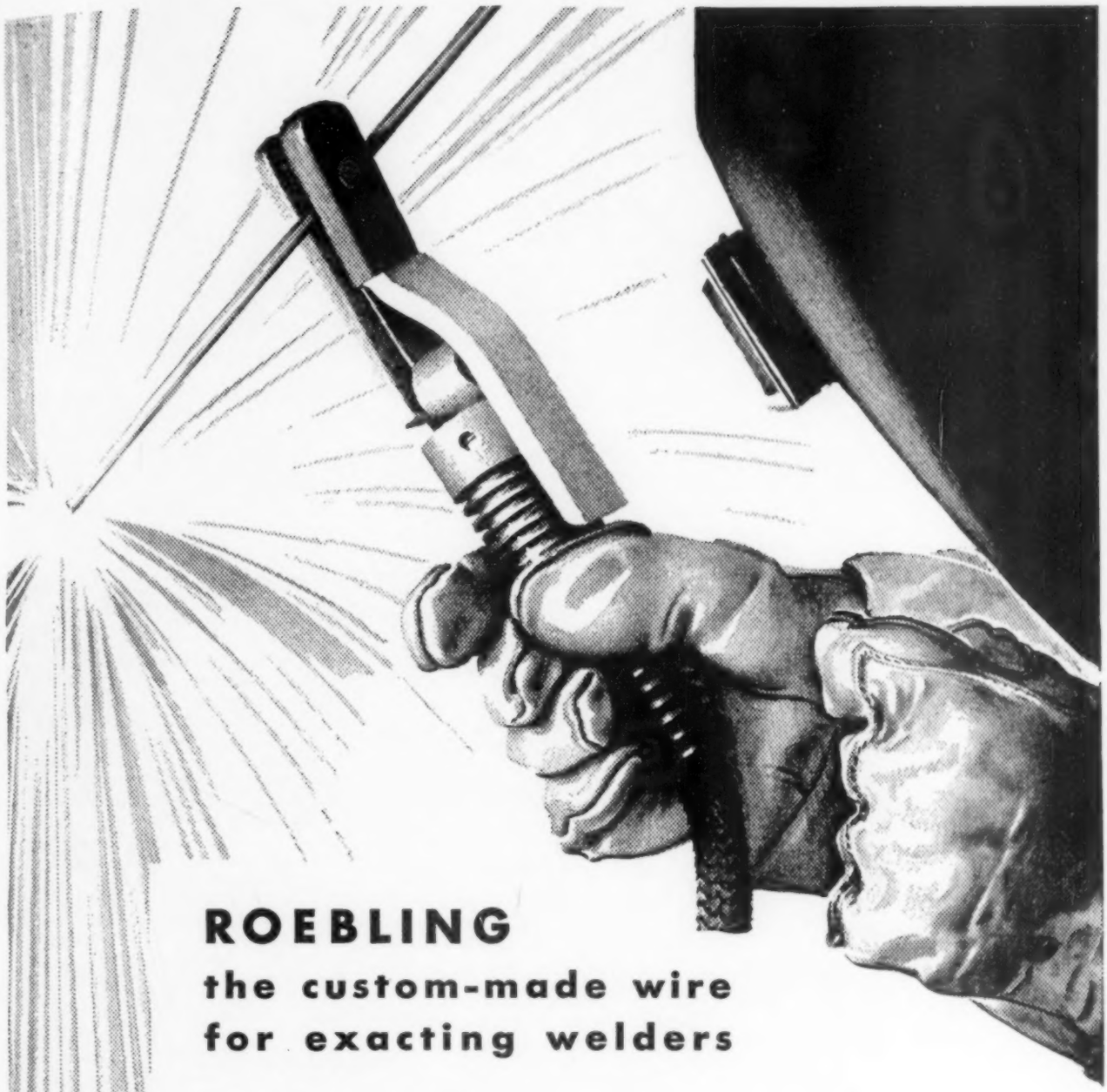

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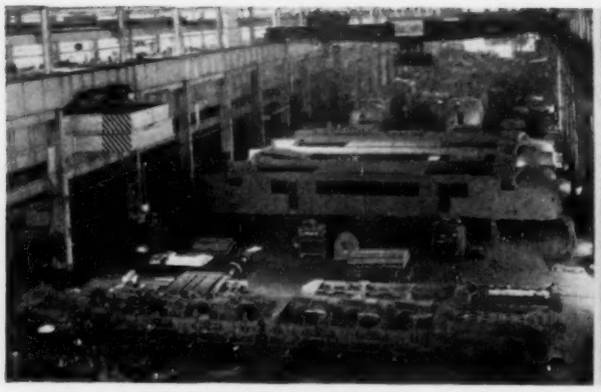


Fig. 3—View of Interior of Erie Shop, Showing Four Paulista Cabs on the Floor, and One of the Welded Underframes in the Foreground

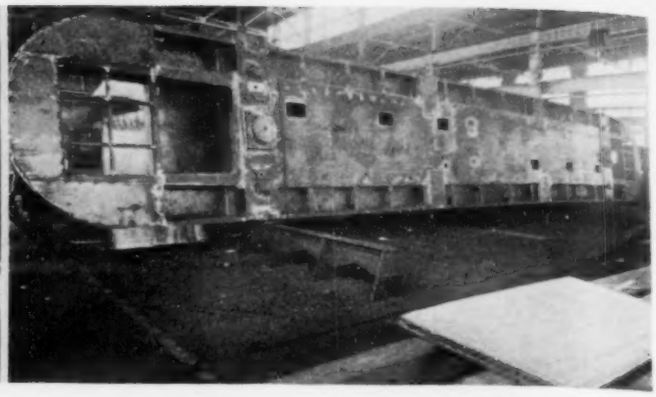


Fig. 4—Welded Underframe Standing on Edge on Assembly Floor

for horizontal welding. They are then placed in a fixture aligned and trammed to require tolerances, and clamped into position for welding.

Intersection portions of parts to be welded together are preheated to approximately 200° C. A large percentage of these connecting welds are laid in vertically, using a d-c arc with heavy-coated electrodes. The side-frame pedestal jaws are cut slightly oversize to allow for adjustment of pedestals laterally as well as lengthwise of the frame. All machining operations, such as boring the cab centerplate seat, drilling for articulation pin and brake arm fulcrum, drilling for equalizer and brake-hanger pins, etc., are performed on the individual parts of subassemblies before they are welded into the main unit frame.

The side frames of the Paulista main driving truck are universal mill-rolled open-hearth steel, 4 inch thick, normalized. The ultimate tensile strength is 55,000 to 65,000 lb. The maximum carbon content is 0.25 per cent. The articulation end frame and middle cross ties are steel plates, hot-rolled, with 50,000 lb. minimum ultimate strength, and of 0.20 to 0.26 carbon content. Wherever possible, all parts are flame-cut to dimensions requiring little or no machining.

Guiding Truck

The guiding truck frame is also completely welded, using side frames made from steel boiler plates $1^1/_2$ inch thick with a tensile strength of 55,000 to 65,000 lb. Cross transom, end frames, gussets and stiffeners are made of commercial structural steel shapes and plates of good welding qualities. In the assembly of these trucks subassemblies are set up in a fixture securely positioned and tacked welded. The frame is then placed on a universal welding table where flat-positioned final welds may be made with heavy-coated electrodes.

Cab Underframe

The cab underframe for this locomotive is one of the most massive single structures yet produced by welding fabrication. The complete structure is about 72 ft. long with two 21-inch H beams forming the main center sills. These beams are reinforced with top and bottom plates of $^1/_2$ inch thickness forming a central duct which is used for distribution of air from the blowers to the traction motors. Side sills of 10-inch standard steel channels are welded to the main structure, bringing the total width to a little over 10 ft. Bolsters supporting center plates, side bearings and lifting lugs are built of heavy H beams and plates. The frame is arc welded throughout.

Cab Structure

The cab sides are built in subassemblies positioned horizontally in a fixture set up on the shop floor. Clamps are used to retain stiffeners or carlines in position while they are being welded to the sheets. The sheets for the rounded ends of the cab are made in sections formed over cast-iron blocks. They are then assembled over a dummy and the seams completely welded.

For the final assembly of the cab the various subassemblies are erected on the cab platform and welded in place. After the cab is completely assembled all seams are ground smooth on the outside; and louvers, windows, belt rail, roof hatch covers, etc., are given a smooth fit in conformance with the streamlined cab structure.

Apparatus Compartments

A feature of the construction of this locomotive which is facilitated by the use of welding is the construction of a completely welded apparatus compartment for the installation of apparatus, wiring and control equipment. When completed, the equipment is placed in position and wired up before the unit is installed in the locomotive. For the final operation the compartment is lowered through the cab roof into its final position and securely welded in place.

Miscellaneous Welded Parts

All brake parts with the exception of brake heads and shoes are fabricated by flame cutting and welding. These parts include the welded main brake arm, adjusting screw and lever connecting rods. Shear welds are used throughout for the fabrication of these parts. Another unusual application of welding is in the construction of spring hangers.

STAINLESS STEEL CARS

The first American stainless steel railway cars to be built for export are now under construction in the E. G. Budd Philadelphia shops, the company revealed recently.

Delivery to the Portuguese National Railway, which has ordered 28 of the American-built lightweight cars, is slated for early summer. Four of the cars will be completely assembled before shipment, the remaining 24 to be shipped knocked-down for assembly in Portugal under supervision of Budd Company engineers.

Differing in strength, weight and gage requirements from the American railway pattern, the Portuguese cars will nevertheless follow in general the Budd type of construction, in which sides, roofs and floor all perform load-carrying functions.

Because engineering requirements on the Portuguese railways differ radically from those on American railroads, and because the cars are somewhat shorter than those used in this country, the cars for the Portuguese Railway will weigh about 60,000 pounds each—some 45,000 pounds less than the lightweight cars built by Budd for use in the United States.

Trucks will be built for the Portuguese track gage of five feet six inches, which is seven and a half inches wider than the standard American gage. Width of the car bodies, however, will be the same as that of American cars.

Interiors of the Portuguese cars will be a combination of American and European styles, providing first, second and third class compartments and accommodations. Doors will be set in the center of the car, instead of at the ends.

WELDING BOOKS

Welding and Soldering Light Metals (Anleitungsblätter für das Schweissen und Löten von Leichtmetallen) 123 pages, 60 illustrations, Berlin 1940, VDI-Verlag, price 2 RM. The VDI Welding Research Committee and Committee on Economical Production cooperated under the direction of Professor A. Matting in preparing this comprehensive collection of information on processes for welding and soldering aluminum and magnesium alloys. Tests and properties of the welds also are discussed.

WHY RESISTANCE WELDING?

There are many reasons for the use of resistance welding—a few of the more important being:

1. Increased production.
2. Reduced production costs.
3. Uniform Quality.
4. Invisible joints.

By the use of special and automatic machines, skilled labor is not required, and other advantages and savings are increased still further.

Next month the RWMA will announce a contest awarding cash prizes—
Look for details in the May issue of

THE WELDING JOURNAL

Resistance Welder Manufacturers' Association

505 Arch Street — Philadelphia, Pa.

MEMBER COMPANIES

Acme Electric Welder Company, Los Angeles
American Electric Fusion Corporation, Chicago
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Company, Detroit
Federal Machine and Welder Company, Warren
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City
Progressive Welder Company, Detroit
Swift Electric Welder Company, Detroit
Taylor-Hall Welding Corporation, Worcester
Taylor-Winfield Corporation, Warren
Thomson-Gibb Electric Welding Co., Lynn
Welding Machines Mfg. Company, Detroit

ASSOCIATE MEMBER COMPANIES

P. R. Mallory and Co., Indianapolis
S-M-S Corporation, Detroit
Electroloy, Inc., New York
Welding Sales and Engineering Co., Detroit

SAVING 20 PER CENT OF THE COST OF A CASTING

By using arc welding in fabricating a devide of a trunnion for a rotary kiln the Menna Welding Company, Toledo, saved 20% of the cost of a casting. The heavy parts shown in the first photograph were

Component Parts of Device of Trunnion for Rotary Kiln, Ready to Be Arc-Welded

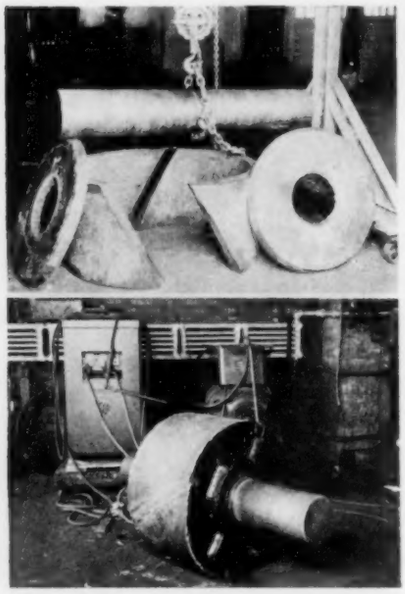


Photo courtesy General Electric Company

Arc-Welded Fabricated Device of Trunnion for Rotary Kiln

cut and shaped by the Manufacturer's Steel Supply Company, Toledo, and arc welded into the complete device (shown in the second photo), using 500-amp. welding transformer and shielded electrodes. The trunnion is made of boiler plate steel $2^1/_4$ inches thick, is 30 inches in diameter, and weighs approximately 2500 pounds.

MANUFACTURING BUILDING

A new manufacturing building, the feature of which is a complete absence of roof trusses to provide maximum interior space, was just recently completed for the Western Austin Company at Aurora, Illinois.

The new building (see Fig. 1), has a floor space of 115,000 square feet and consists of three units. One unit is a modern up-to-date paint shop 75 ft. x 180 ft. fitted with the latest type of equipment for finishing manufactured products.

The second unit is a warehouse for the storage of raw materials. It is 150 ft. x 250 ft. having three bays; 60 ft., 43 ft. and 46 ft. in width. Two of the bays are equipped with craneways and the third is designed to permit crane installation when needed.

The third unit is for product assembly. It is 120 ft. x 500 ft. having two bays; one 40 ft. and the other 80 ft. wide. Both bays are served by cranes. Also included in this unit are a cafeteria, commissary,

Fig. 1—Interior of the New Western Austin Building at Aurora Showing Complete Absence of Roof Trusses in an Interior of Attractive "Streamlined" Appearance

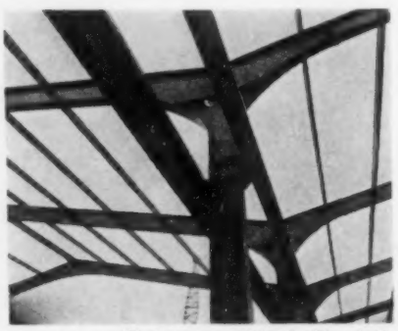
Fig. 2—Columns of the New Western Austin Structure at Aurora Featuring a Top Section Fabricated Entirely of Steel Plate Arc Welded

large meeting room, employment and first aid rooms. Of the three units, the two larger ones are attached directly to the existing Western Austin structure.

The steel frame was fabricated and erected largely by arc welding.

Elimination of roof trusses (see Fig. 2), was made possible by ability to fabricate columns and roof beams which would meet load requirements without the addition of the extra members necessary in the conventional roof truss.

Details of the columns can be seen in Figs. 2 and 3. The main feature is the top section which can be fabricated only by welding. This member is not available as a standard rolled section and the excessive costs for riveted fabrication would prevent its use for such a member. It is composed



Photos courtesy Lincoln Electric Co.

Fig. 3—Framework Details of the New Western Austin Building

entirely of plate cut to proper size and shape and fused together. The use of flame cutting permits economical production of the Y-shaped web segment, while bending equipment is utilized to obtain the proper form in the flange members. The flange plates are joined to the web of the section by continuous fillet welds on both sides. In production of the columns, these Y-shaped "tree form" sections are simply arc welded to standard H beams to complete the columns.

The advantage of this design is reflected in the interior of the building in which it is used. Roof loads are transmitted from the roof beams in the smooth curving lines permitted in the upper fabricated section of the column. Absence of roof trusses permits installation of craneways in the apex of the roof, thus saving the space which would be taken up in conventional roof truss construction. This feature is further reflected in reduced structure height, and therefore, less cubical content, which permits lower building maintenance costs for painting and heating together with an attractive "streamlined" appearance.

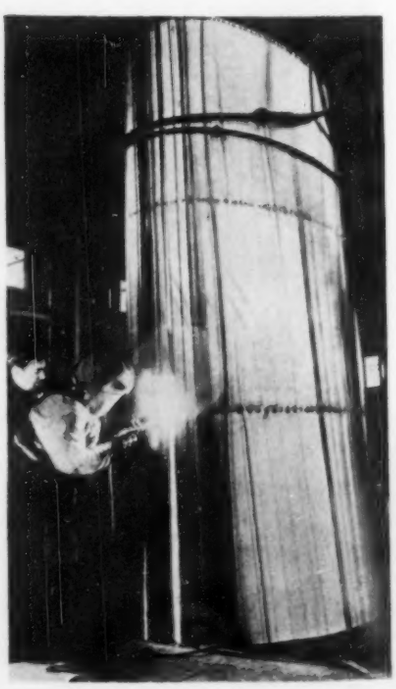
The roof, which is of 20-year pitch and slag built-up type, has a galvanized metal deck with $1^1/_2$ inches insulated board.

A feature of this structure is the extensive utilization of natural light. Total area of the roof skylights is equal to 30% of the interior floor space. The continuous horizontal runs of sash in the brick curtain walls also adds to the natural illumination.

E. O. Sessions and Company, Consulting Engineers of Chicago, designed this structure and erection was under the personal supervision of J. H. Johnson, Chief Structural Engineer for the designers.

DAIRY TRUCK TANK

We are indebted for the illustration shown below to the Republic Steel Corporation, Cleveland, Ohio. The view



Courtesy: (A) Wallace Supplies Mfg. Co., (B) Midwest Piping & Supply Co., (C) Franks Mfg. Co.

THEY'RE PIPING AWAY THE TWIST & SAG

● By building frameworks out of pipe welded together, machine designers are taking the "give" out of their products and putting feathers in their caps.

Engineers have long recognized that tubular members are exceptionally rigid—ideal for machine frames. Now, welding makes this construction possible. Example:

Effective use of rigid tubular members for the frame of the Wallace Supplies pipe-bending machine shown in (A) yielded the following benefits as compared to the former welded frame using structural shapes:

23% reduction in set-up time
20% reduction in welding time
10% reduction in weight
Deflection reduced from .103 to .013 inch
Torque capacity increased from 7,000,000 to 13,000,000 inch pounds

By minimizing twist and sag, tubular construction is also improving earth-moving scrapers (B), portable derricks (C), furniture, aircraft, and hundreds of other new products and structures. And, there are any number of other shapes* which can be fabricated by welding into rigid, light-weight designs for improved performance, greater sales volume and lower costs.

Look into *"Shield-Arc"* welding today. Call the nearest Lincoln office for counsel or write THE LINCOLN ELECTRIC COMPANY, Dept.DD14, Cleveland, O. Largest Manufacturers of Arc Welding Equipment in the World.

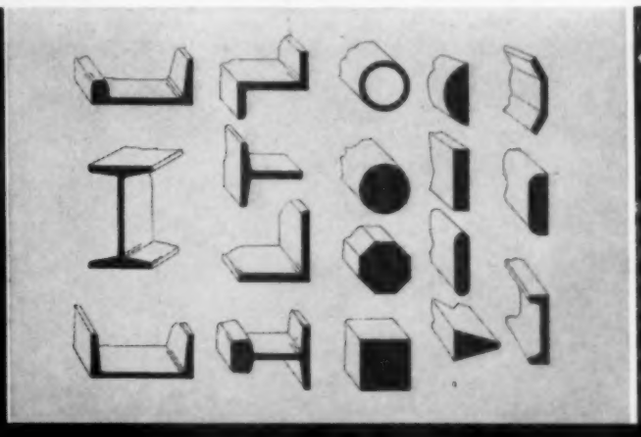
LINCOLN *"SHIELD-ARC"* WELDING

Unites design ingenuity with superior structural materials for progress

WELDING LIBERTY. The New 200-amp. *"Shield-Arc Jr.,"* equipped with self-indicating Job Selector and Current Control, can be "set" for any TYPE of arc or any AMPERAGE to suit every job. This freedom means a wider use of arc welding for lower costs. Price only $243 f.o.b. Cleveland, freight prepaid.

* **DESIGN LIBERTY.** You can use any of these standard steel shapes . . . fabricate special shapes . . . use pressed steel parts or steel castings . . . use any analysis of steel . . . to design for functional requirements with welding. This freedom means progress.

SAVES 66⅔ TIME. Here, arc welding with a *"Shield-Arc Jr."* and "Stainweld A" Electrodes replaces method of attaching steel plates to loudspeaker magnet (Permang) by brass screws. Saves 66% in time and gives better performance. Courtesy Jensen Radio Mfg. Co., Chicago, Ill.



illustrates the welding of stainless steel shell for a truck dairy tank as used by all of the large milk companies. The stainless is Republic's Enduro Stainless Steel. Fabricator is Glascote Products Company.

SPEEDING CONSTRUCTION AT SHASTA DAM

Second only to Boulder Dam in height and exceeded only by Grand Coulee in

Repairing Tractors

mass, Shasta Dam has made necessary the relocation of the Southern Pacific Railroad along the Sacramento River in California. Preliminary work on the relocation project has been started at Pollock, Calif., by

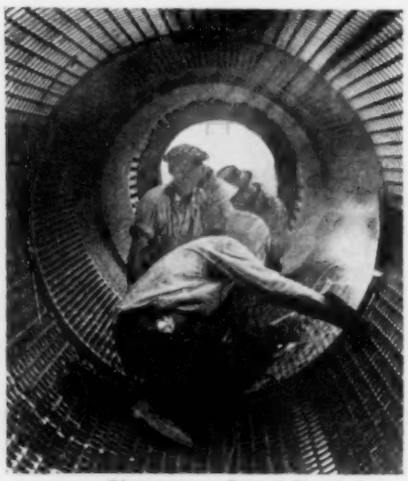


Photo courtesy General Electric Co.

Welding Gravel Screens

the C. A. Dunn Construction Company. To help speed up construction and avoid delays, shielded electrodes are used for work such as welding gravel screens and repairing tractors.

GRINDING WELDS

In line with their announced policy of offering special abrasive wheels for industry's "problem" jobs, the newly-formed Atlantic Abrasive Corp., 538 Pearl St., South Braintree, Mass., has made available a new type wheel especially designed for weld grinding and snagging.

This wheel, designated as Atlantic Type AK, makes use of the company's patented synthetic bonding material to permit maximum working speed and pressure without danger of burning.

NEW PRODUCTS

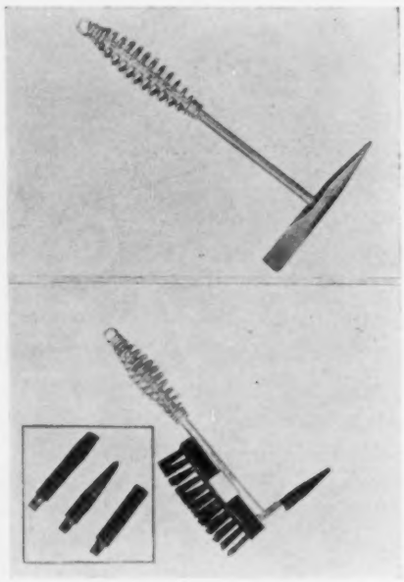
The Society assumes no responsibility for the validity of claims in this Section

WELD CLEANING TOOL

The Atlas Welding Accessories Company, 307 Boulevard Building, Detroit, Michigan, announce the production of a line of weld cleaning tools.

They consist of the "Atlas Tomahawk," which is a chipping hammer for removing slag from welds, and the "Atlas Weld

Chipping Hammer



Chipping Hammer and Wire Brush

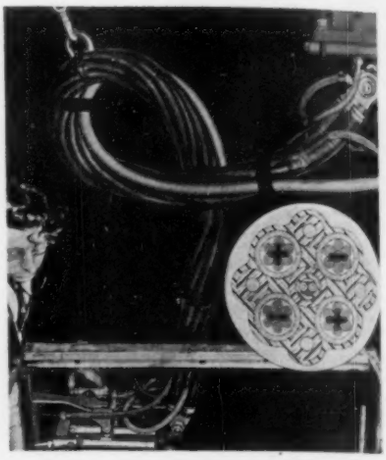
Cleaning Tool," which is a combination chipping hammer and wire brush. This Weld Cleaning Tool has removable tool steel bits which can be furnished in various type points. They are threaded and screwed into the head. The brushes can also be replaced.

These tools will be sold through welding supply houses.

WELDING CABLE

A new type "all-in-one" welding cable employing a unique method of neutralizing induction to eliminate cable kicking, at the same time reduce welding current losses, permit increased ease (and speed) of gun handling and eliminate cable wear is announced by Progressive Welder Company, 3034 E. Outer Drive, Detroit, Michigan.

Due to its unusually compact design, the new unit, to be known as the "No-Kik" welding cable, eliminates interference with work to a large extent. Welding currents cables, water cooling lines and control cable are all sheathed in a single, seam-



Welding Cable

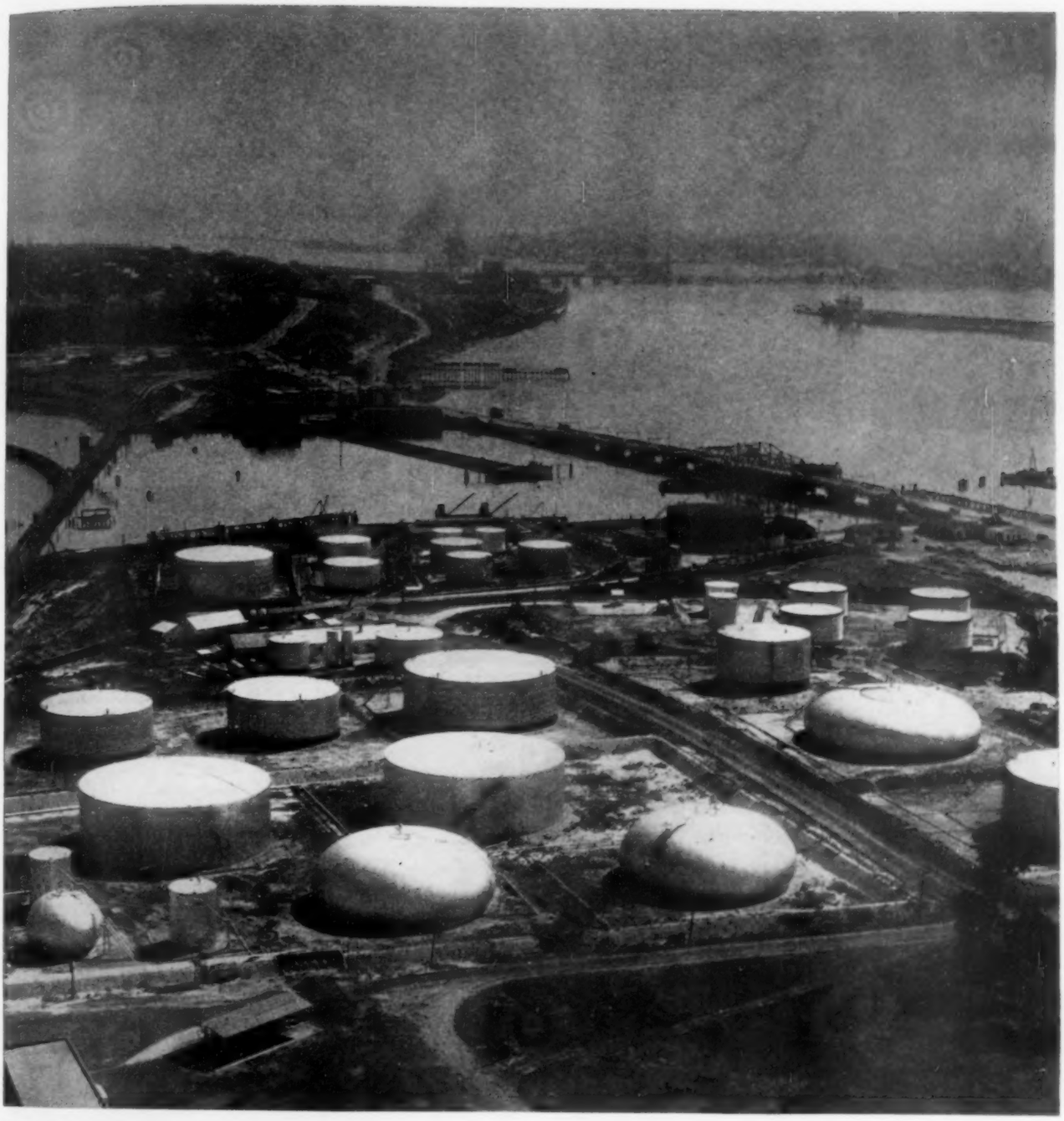
less rubber covering of maximum flexibility.

Instead of the customary two current carrying cables, the new "No-Kik" has four. The method of arranging the duplicate positive and negative cables neutralizes each others' magnetic fields. This results in less wear (through cable "kicking") and a 60% reduction in welding current costs, it is claimed. At gun and transformer ends, each pair of positive and negative cables are joined together to provide a single bolt, solid attachment The seamless rubber covering maintains cables in their relative position between the gun cooling lines (shown between the cables in the assembly section) and the control cable which forms the core of the unit. Water cooling for the current cables is provided by means of water circulating through the cables themselves.

SHEET METAL WELDING

A new booklet, "Sheet Metal Welding Fundamentals," has just been published by The Linde Air Products Company, a Unit of Union Carbide and Carbon Corporation. The booklet covers such subjects as design factors, the control of expansion and contraction, the use of jigs, the weldability of the material, and the welding procedure. It should be of particular interest to the aircraft industry and all fabricators of light-gage metal, whether sheet metal or light-wall tubing.

Also included in the booklet is a supplementary outline for teaching the welding of sheet metal and tubing. Recommended as a brief, to-the-point aid for instructors in welding schools and colleges, the outline contains suggestions for lectures, demonstrations, shop work and study references for 30 lessons



STEEL TANKS

. . . . . of welded construction

Welding lends itself readily to modern steel tank construction. Take, for instance, the Hortonspheroids shown in the above view. The plates are held in place firmly and accurately during erection by special equipment and welded into a smooth, continuous shell with no leaky joints.

CHICAGO BRIDGE & IRON COMPANY

Chicago	2455 Old Colony Bldg.	Birmingham	1507 North 50th Street	Philadelphia	1668-1700 Walnut St. Bldg.
New York	3398-165 Broadway Bldg.	Tulsa	1654 Hunt Bldg.	Boston	1565 Consolidated Gas Bldg.
Cleveland	2282 Rockefeller Bldg.	Houston	2919 Main Street	San Francisco	1097 Rialto Bldg.
Dallas	1489 Liberty Bank Bldg.	Detroit	1556 Lafayette Bldg.	Los Angeles	1455 Wm. Fox Bldg.

Fabricating plants in CHICAGO, BIRMINGHAM, and GREENVILLE, PA.

Copies of this 16-page booklet, Form 4435, are available upon request. Write the nearest office of The Linde Air Products Company or the company's headquarters at 30 East 42nd Street, New York.

WELDING BLOWPIPE AND CUTTING ATTACHMENT

Designed for Light-to-Medium Work

A new medium-pressure oxyacetylene blowpipe for welding light-gage metal, and a cutting attachment for cutting iron and steel up to 1 inch in thickness, have just been announced by The Linde Air Products Company, a Unit of Union Carbide and Carbon Corporation.

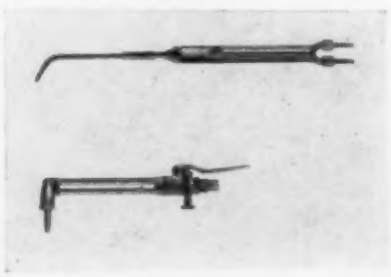


Fig. 1 (Above) The Prest-O-Weld (Type W-109) Welding Blowpipe Will Join Metals up to ¾ Inch in Thickness
(Below) The Prest-O-Weld (Type CW-109) Cutting Attachment Will Cut Iron and Steel Up to 1 Inch in Thickness

The blowpipe, known as the Prest-O-Weld (Type W-109) welding blowpipe, is specially designed for welding in light production work and in aircraft construction. Its field of usefulness includes, however, all applications in which metals up to $^{3}/_{8}$ inch in thickness are to be joined. Field tests have proved it equally well adapted for sheet metal welding, automobile fender and body work, radiator repair, and dental and jewelry work.

EYESHIELD

A new type of eyeshield characterized by its lightness, comfort and low cost, is announced by Jackson Electrode Holder Co., Detroit, Mich. It is recommended particularly for workmen engaged in buffing, polishing and light grinding operations, woodworking, and for helpers around spot, flash and gun welding machines.

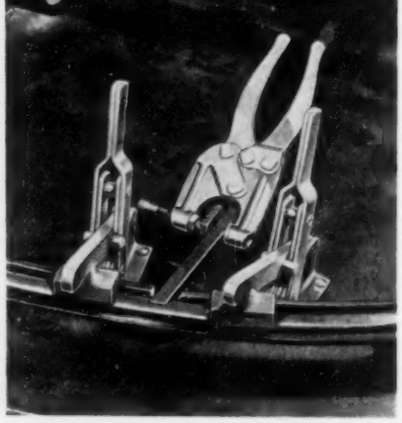
The shield fits the face snugly and comfortably, provides complete eye protection, does not interfere with prescription glasses. Wide vision in all directions is afforded through lenses of flexible shatterproof Plastacele. Ventilation provided through screened grommets. The shield folds flat, fits the vest pocket.

Jackson Folding Eyeshield

CLAMPING TOOLS

In response to popular demand the Detroit Stamping Co. engineers have developed two new clamping tools, both of which are especially suitable for use in the Aircraft industry; also for clamping and holding other types of work in production, where limited clamping space or nature of job renders larger size clamps unusable.

Rapid action De-Sta-Co Toggle Clamp No. 220, "Aviation" model, of which there are two shown in the illustration above measures but $1^{29}/_{32}$ inches by $1^{5}/_{8}$ inches at base, well proportioned throughout and especially engineered for quick clamping, positive holding and instant release. Raising of the operating handle delivers a pressure ratio of 33 to 1 to the clamping arm.



Rapid action De-Sta-Co Toggle Pliers No. 460, "Light Duty" model, as shown in the center of the picture above, measures but $6^{15}/_{32}$ inches long over-all.

VICTOR EQUIPMENT CATALOG

The Victor Equipment Company, 844 Folsom St., San Francisco, Calif., has just issued a handsome catalog of 40 pages in colors, giving a complete description of their full line of equipment, including, torches, nozzles, cutting tips, torch holders, cylinder trucks, regulators, adaptors, valves and combination units. The catalog also contains a considerable amount of valuable technical data.

X-RAYS USED IN WELDING TESTS BY HOUSTON FIRM

X-ray is being used by Hedrick & Lindsley, Inc., Houston architects, to find defects in welding on an air-conditioning modernization job that is in progress on the Shell Building.

X-ray is being used extensively in the inspection of welds in connection with the construction of an air shaft and for a new elevator shaft. The Industrial Welding and Testing Laboratory is doing the inspection work.

EMPLOYMENT SERVICE BULLETIN

SERVICES AVAILABLE

A-346. Welding Engineer, M.E., Ph.D., specialized metallurgist, member A.W.S. American-European experience. Will represent progressive manufacturer, Eastern territory, salary and commission, or accept promising position.

A-347. Mechanical Engineer. Graduate June 1940, age 25, married. Member A.S.M.E., Tau Beta Pi. Four years' experience in factory maintenance and construction welding. Expert Acetylene and Arc welder on all types of ferrous and nonferrous metals. Desires engineering, maintenance or supervisory work in welding field.

A-348. Welding salesman desires position. Qualified welder well known in the South and Southwest. 36 years of age. Has had extended experience in sales work and as a welder and instructor.

A-349. Electric and Acetylene Welder. Formerly employed as a welder with the Lancaster Iron Works and the Carnegie-Illinois Steel Corp. Took postgraduate course in mathematics and scientific subjects.

A-350. Graduate student at University of Illinois, age 22, to receive M.S. in metallurgical engineering in June will be available for position in welding industry. Has had two years experience as special research assistant in welding field, is expert in interpretation of structures in steels resulting from fusion welding, well-grounded in fundamentals and has developed a careful, precise research technique.

POSITION VACANT

V-93. Assistant Chief Draftsman for water tube boiler and pressure vessel work. Must be thoroughly familiar with A.S.M.E. Code and capable of directing checkers and board men. Salary $225 a month. Location East.

FOR WELDER TRAINING IN METROPOLITAN NEW JERSEY

The Welding Training Institute, opened April 1st at 23–25 Sussex Ave., Newark, N. J., has announced a system of instruction for welding operators which has been developed to meet the varied requirements of industrial plants in the Northern New Jersey area. Courses for beginners are so arranged that students progress according to their individual abilities rather than on a set schedule of hours, the completion of each unit of instruction being determined by proficiency tests. Advanced courses for experienced welders are planned individually, to correct faults in workmanship and to develop ability in the more difficult types of operation.

Also offered to experienced welders are special courses in low and high pressure pipe welding, structural welding, aluminum welding, stainless steel welding, silver brazing, etc., and courses leading to qualification under various codes.

Sections—CHAIRMEN, SECRETARIES AND REGULAR MEETING DATES

BIRMINGHAM — **3rd Fri.**
CHAIRMAN—J. W. ADAMS, 209 No. 52nd St., Birmingham, Ala.
SECRETARY-TREAS.—W. L. POOLE, Air Reduction Sales Company, 2825 No. 29th Ave., Birmingham, Ala.

BOSTON — **2nd Mon.**
CHAIRMAN—F. B. MEHAFFEY, Air Reduction Sales Co., 122 Mt. Vernon St., Upham Crs., Dorchester, Mass.
SECRETARY—P. N. RUGG, 8 Eastern Ave., Wakefield, Mass.

CHATTANOOGA, TENN. — **1st Wed.**
CHAIRMAN—A. R. McLAIN, 622 Georgia Avenue, Apt. 110 Chattanooga, Tenn.
SECRETARY—J. H. WEIGEL, 117 Ochs Highway, Chattanooga, Tenn.

CHICAGO — **3rd Fri.**
CHAIRMAN—E. A. BALSLEY, Link-Belt Co., 300 W. Pershing Rd, Chicago Ill.
SECRETARY—M. S. HENDRICKS, Welding Engineer, Room 731, 506 South Wabash Avenue

CINCINNATI, OHIO
CHAIRMAN—JAMES K. ROSS, Box 172, Oakley Sta., Cincinnati, Ohio.
SECRETARY—LEWIS B. BLAKENEY, Westinghouse E. & M. Co., 207 N. 3rd St., Cincinnati, Ohio

CLEVELAND — **2nd Wed.**
CHAIRMAN—F. L. PLUMMER, 2591 Charney Rd.
SECRETARY-TREAS.—A. LESLIE PFEIL, Universal Power Corporation, Cleveland, Ohio

COLORADO — **3rd Wed.**
CHAIRMAN—J. H. JOHNSON, Johnson Supply Co., Denver, Colo.
SECRETARY-TREAS.—H. W. CREAGER, Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.

COLUMBUS, OHIO — **2nd Fri.**
CHAIRMAN—F. S. CALDWELL, Jeffrey Mfg. Co., Columbus, Ohio
SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

CONNECTICUT — **1st Tues.**
CHAIRMAN—JOHN J. VREELAND, Chase Brass & Copper Co., Waterbury, Conn.
SECRETARY—H. A. PENNINGTON, A. B. King & Co., 196 Chapel Street, New Haven, Conn.

DETROIT — **1st or 2nd Fri.**
CHAIRMAN—H. P. DOUD, General Electric Co., 700 Antoinette, Detroit
SECRETARY—O. L. SMITH, Weldit Acetylene Co., 638 Bagley, Detroit, Mich.

GEORGIA — **1st Mon.**
CHAIRMAN—D. B. HUNT, 484 Brentwood Dr. N. E., Atlanta, Ga.
SECRETARY—H. J. LEE, P. O. Box 4564, Atlanta, Ga.

HAWAII — **Last Thursday**
CHAIRMAN—ROBERT A. PLAUS, W. A. Ramsay, Ltd., Honolulu, T. H.
SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., P. O. Box 2454, Honolulu, T. H

INDIANA
CHAIRMAN—A. C. RASMUSSEN, Insley Mfg. Corp., Indianapolis, Ind.
SECRETARY—G. HAISLUP, Electric Steel Castings Co., Speedway City, Indianapolis, Ind.

KANSAS CITY, MO. — **3rd Mon.**
CHAIRMAN—J. L. FIZZELL, National Steel Prods. Co., Kansas City, Mo.
SECRETARY—JAMES P. KIRK, Air Reduction Sales Co., Kansas City, Mo.

LAKE SHORE
CHAIRMAN—A. W. WIEMANN, Armour Leather Co. Sheboygan, Wis.
SECRETARY—R. E. KING, 1308-A Hamilton St. Manitowoc, Wis.

LOS ANGELES — **3rd Thurs.**
CHAIRMAN—C. P. SANDER, Western Pipe & Steel Co., Los Angeles. Calif.
SECRETARY,—J. C. GOWING, 644 E. Florence Ave., Los Angeles, Calif.

LOUISIANA — **1st Fri.**
CHAIRMAN—O. B. McLAUGHLAN, Freeport Sulphur Co., Port Sulphur La.
SECRETARY—CLYDE PINE, The Isaac Delgado Trade School, New Orleans, La.

MARYLAND — **3rd Fri. except April**
CHAIRMAN—C. N. HILBINGER, T. A. Canty, Inc., Baltimore, Md.
SECRETARY-TREAS.—R. A. MANSFIELD, Southern Oxygen Co., Baltimore, Md.

MEMPHIS
CHAIRMAN—E. H. GILL, National Butane Gas Co., Memphis, Tenn.

MILWAUKEE — **2nd Wed.**
CHAIRMAN—R. W. STERNKE, Lakeside Bridge & Steel Co., Milwaukee, Wis.
SECRETARY—GILBERT F. MEYER, Machinery & Welder Corp., Milwaukee, Wis.

NEW YORK — **2nd Tues. except when Joint Meeting is held**
CHAIRMAN—CHARLES KANDEL, Craftsweld Equipment Co., Long Island City, N. Y.
SECRETARY—G. V. SLOTTMAN, Air Reduction Sales Co., 60 East 42nd Street, New York, N. Y.

NORTHWEST — **3rd Wed.**
CHAIRMAN—T. J. WARMINGTON, Wm. Bros. Boiler & Mfg. Co., Minneapolis, Minn.
SECRETARY—ALEXIS CASWELL, Manufacturers Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis, Minn.

NORTHERN NEW JERSEY
CHAIRMAN—F. C. FYKE, Standard Oil Development Co., Elizabeth, N. J.
SECRETARY—H. S. CARD, 449 Elmora Ave., Elizabeth, N. J.

NORTHERN N. Y. — **Last Thurs.**
CHAIRMAN—R. W. CLARK, General Electric Company, Schenectady, N. Y.
SECRETARY—G. A. ROSS, General Electric Co., Schenectady, N. Y.

OKLAHOMA CITY — **1st Fri.**
CHAIRMAN—K. B. BANKS, P. O. Box 1377, Oklahoma City, Okla.
SECRETARY—C. C. WILLIS, P. O. Box 1498, Oklahoma City, Okla.

PEORIA—CENTRAL ILLINOIS
CHAIRMAN—E. E. ISGREN, R. G. Le Tourneau, Inc., Peoria, Ill.
SECRETARY—ALBERT A. LOESCH, R. G. LE TOURNEAU, Peoria, Ill.

PHILADELPHIA — **3rd Mon.**
CHAIRMAN—H. R. SALISBURY, Air Reduction Sales Co., Allegheny & 17th Sts., Phila., Pa.
SECRETARY—H. E. HOPKINS, Arcos Corp., 401 N. Broad St., Phila., Pa.

PITTSBURGH — **Middle Wed.**
CHAIRMAN—G. F. WOLFE, Dravo Corp., Engineering Wks. Div., Pittsburgh, Pa.
SECRETARY—J. F. MINNOTTE, Minnotte Bros., 1201 House Bldg., Pittsburgh

PUGET SOUND
CHAIRMAN—H. HAYNES, Commercial Boiler Wks., 53 W. Lander St., Seattle, Washington
SECRETARY—L. A. BURQUE, Westinghouse Elec. & Mfg. Co., Seattle, Washington

QUAD CITIES
CHAIRMAN—A. R. GUSTAFSON, 840 Third Ave., Moline, Illinois
SECRETARY—J. W. SHUGARS, Lincoln Elec. Co., Moline, Illinois

ROCHESTER, N. Y. — **1st Thurs.**
CHAIRMAN—EDWIN ALLAN, Allan Iron & Welding Wks., Inc., 133 Murray St.
SECRETARY—PAUL W. JAMES, Lincoln Electric Co., 17 Lake View Park, Rochester, N. Y.

SAN FRANCISCO — **Last Fri.**
CHAIRMAN—T. R. ROONEY, Western Pipe & Steel Co., San Francisco,, Calif.
SECRETARY—J. G. BOLLINGER, Air Reduction Sales, Park & Halleck Sts., Emeryville, Calif.

SAN JOAQUIN VALLEY
CHAIRMAN—G. D. ATMORE, 401 Santa Barbara St., Santa Paula, Calif.
SECRETARY—H. S. NIX, Taft Union H. S. & Jr. College, Box 1364, Taft, Calif.

ST. LOUIS — **2nd Fri.**
CHAIRMAN—N. F. MOSS, 7508 Wayne, St. Louis, Mo.
SECRETARY—M. E. MEYERSON, 2317 Chouteau Ave., St. Louis, Mo.

SOUTH TEXAS
CHAIRMAN—B. W. FARQUHAR, Gulf Oil Corp., Port Arthur, Texas
SECRETARY—T. D. KETCHBAW, Industrial Welding & Testing Lab., Houston, Texas

TULSA, OKLAHOMA
CHAIRMAN—G. L. WILEY, Box 226, W. Tulsa, Okla.
SECRETARY—O. L. ROGERS, Big Three Welding & Equipment Company, Tulsa, Okla.

WASHINGTON, D. C. — **2nd Tues.**
CHAIRMAN—C. A. LOOMIS, Bureau of C. & R. Navy Dept., Washington, D. C.
SECRETARY—G. E. KNOX, Bureau of Yards & Docks, Navy Dept., Washington, D. C.

WESTERN NEW YORK — **Last Mon.**
CHAIRMAN—J. R. DAWSON, Union Carbide and Carbon Res. Labs., Niagara Falls, N. Y.
SECRETARY—C. S. FREEMAN, The Lincoln Electric Company, Buffalo, N. Y.

WICHITA, KANSAS
CHAIRMAN—L. E. KIRK, Vickers Petroleum Co., Wichita, Kansas
SECRETARY-TREAS.—K. O. HOUSER, Kansas Gas & Electric Co., Wichita, Kansas

YORK—CENTRAL PENNA.
CHAIRMAN—J. W. HENNESSEY, York Safe & Lock Co., York, Pa.
SECRETARY—C. B. HERRICK, 628 S. Pershing Ave., York, Pa.

YOUNGSTOWN (OHIO) — **2nd Mon.**
CHAIRMAN—E. W. TROSS, United Eng. & Fdy. Co., Youngstown, Ohio
SECRETARY-TREAS.—C. R. RIGGLE, Ohio Edison Co., Youngstown, Ohio

» » » SECTION ACTIVITIES « « «

CHATTANOOGA

The Chattanooga Section of the AMERICAN WELDING SOCIETY held its regular monthly meeting on February 18, 1940. The principal speaker of the evening was Major Fred. A. McMahon, Executive Officer of the Cincinnati Ordnance District. The subject of his talk was "Industrial Mobilization."

CLEVELAND

Mr. H. L. Rogers, Welding Superintendent for the Marion Steam Shovel Co., presented an interesting address on the subject, "Welding of Large Steam Shovels," at the March 13th meeting of the Cleveland Section, held at Fenn College. Mr. Rogers discussed gas cutting, forging and arc welding large parts in the fabrication of steel to replace heavy castings.

The 1940 Spring Educational Course of the Cleveland Section will be presented by Mr. O. N. Stone of the Wellman Engineering Co. The following is a list of the lectures and their dates. The lectures are free to all members of the AMERICAN WELDING SOCIETY accredited to the Cleveland Section and to Cleveland Section Affiliates. Others may attend the course upon payment of $2.50.

April 1st—Elements of Structural Welding Design.
April 8th—Examples of Structural Welding Applied to Buildings.
April 15th—Examples of Welding Applied to Tanks and Pressure Vessels.
April 22nd—Elements of Mechanical Welding Design.
April 29th—Examples of Welding Applied to Machine Parts Subjected to Static Loads.
May 6th—Examples of Welding Applied to Machine Parts Subjected to Dynamic Loads.

The lectures are to be given at Fenn College, E. 24th St. and Euclid Ave., 8:15 P.M.

A Welding Symposium will be given on the afternoon and evening of May 3rd at the Hotel Statler. Further details will be given later.

COLUMBUS

The Columbus Section celebrated its second birthday recently and are to be congratulated on the good work they have done in their two years of existence. At the March 8th meeting held at the Hotel Fort Hayes, Mr. E. A. Mallett, Vice-President, Taylor-Winfield Corp., presented an interesting address on "The Latest Developments in Resistance Welding."

DETROIT

The regular monthly meeting of the Detroit Section was held on March 15th in the Detroit-Leland Hotel. Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corporation, spoke on the subject, "Welded Joints, Which Ones to Use and When and Why." Through the courtesy of The Linde Air Products Company, a short movie on the "Unionmelt" welding process was shown.

HAWAII

The Hawaii Section reports that at their November meeting they had a metal spraying demonstration, which was preceded by a meal furnished by the Society. This affair produced a generous turnout, ten members and 69 guests, of which about half are good prospects. Mr. E. W. Evans conducted the demonstration and really put on a show.

LAKE SHORE

An organization meeting of the Lake Shore Section with headquarters at Manitowoc, Wis., was held on February 26th. Mr. K. L. Hansen, Middle Western Divisional Vice-President of the AMERICAN WELDING SOCIETY, presented a very interesting address.

The following Officers and Executive Committee were elected:

Chairman, Albert W. Wiemann; Vice-Chairman, L. B. Olsen; Sec.-Treas., Robert E. King.

Executive Committee: (2-year term) A. L. Pitz, Marvin H. Busse, W. J. Wolter; (1-year term) E. J. Biever, E. H. Schiemann, W. C. Huchthausen.

MILWAUKEE

A joint meeting with the American Society of Civil Engineers was held on February 23rd at the City Club of Milwaukee. Mr. N. L. Boardman, of the Federal Bureau of Investigation, gave an after-dinner talk on "Work and Function of the F. B. I." The welding address was presented by Mr. H. W. Lawson, Bethlehem Steel Company, who spoke on "Modern Steel Structures." Structural details were discussed and pictures of various types of structures were shown.

The March 13th meeting was a joint meeting with the Wisconsin Engineering Conference at the Hotel Pfister. A lecture and demonstration on the control of light, "The Miracle of Light," was presented after the dinner. The welding address was given by Mr. R. T. Gillette, General Electric Company, on "Recent Improvements in Manufacturing by Resistance Welding."

NEW YORK

The New York Section, AMERICAN WELDING SOCIETY, held a meeting on Tuesday, March 12, 1940, at 7:30 P.M. in Room 501, Engineering Societies Building, 33 West 39th Street, New York, N. Y. The chairman was Mr. J. L. Wilson, Assistant Chief Surveyor, American Bureau of Shipping. The speaker was Mr. E. C. Rechtin, Assistant to Vice-President, Bethlehem Steel Company, Shipbuilding Division. Mr. Rechtin's subject was "Welding and the Business of Shipbuilding." His lecture included a study of the effects of welding on the economics of ship construction. It also summarized the latest applications of automatic welding in the shipyards of the Bethlehem Steel Company and others. Following the paper, an interesting motion picture entitled "Quincy Takes to Sea" was shown. This film gave a striking illustration of some of the severe conditions which ships encounter at sea during heavy weather.

Members of the Society of Naval Architects and Marine Engineers were also invited to the meeting. The keen interest in Mr. Rechtin's subject was amply demonstrated by the attendance of approximately 500, including members of both societies. A very interesting discussion followed in the course of which the many advantages of welding in ship construction were strikingly brought out.

NORTHERN NEW YORK

On January 11th the Northern New York Section sponsored a combined meeting of the Schenectady Engineering Societies, including A. I. E. E., A. S. M. E., N. Y. S. S. P. E. and A. W. S. Mr. A. R. Smith, Managing Engineer of the Turbine Department of the General Electric Company, spoke on "Recent Developments in the Mercury Vapor Process of Power Generation." The talk was illustrated with slides.

The February 29th meeting was devoted to an illustrated discussion of the "Welding of Low Alloy Steels" by Dr. J. C. Hodge, Metallurgist and Welding Engineer of the Babcock & Wilcox Company. The Schenectady section of A. S. M. E. were guests as this meeting.

NORTHWEST

The Northwest Section is conducting a practical course on welding and related subjects, consisting of eight lectures and demonstrations on welding steel, copper,

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U·S·S ROLLED STEELS

WELDED rolled steel construction is a 'natural.' That's why it has gained a wide acceptance in such a comparatively short time. Designers, fabricators and welders were quick to see that rolled steel construction placed at their disposal the entire range of metallurgy's special steels — permitted them to use these steels combined with one another, or with plain steels or castings, to improve their product and reduce its cost.

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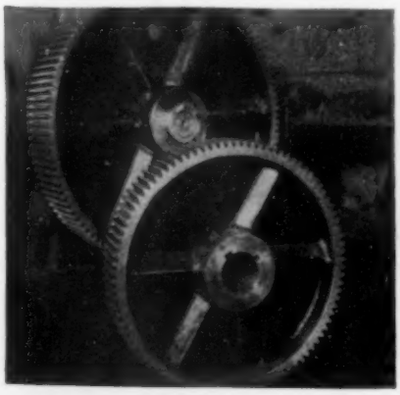
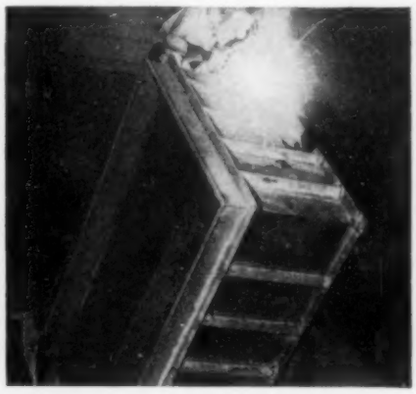
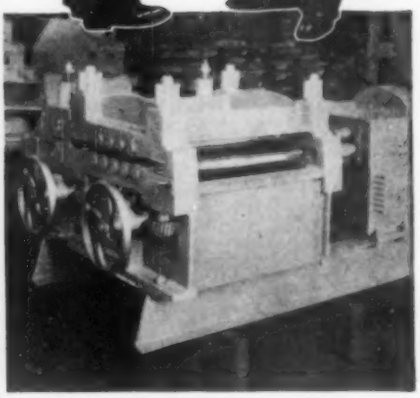
The photographs on this page illustrate the wide range of applications to which Rolled Steels are being put. We'll be glad to give you further information on these and many more jobs. Or, if you desire, a rolled steel specialist will talk with you personally about your own product—show you how, where and why construction with U·S·S Rolled Steel can improve it.



In large or small gear fabrication, rolled steel and welded construction can cut fabricating time and costs and give the gears longer life and greater strength. Records in our files show savings of 25% and more achieved with this type of construction.



Welding speeds construction of limestone cars . . . gives them longer life. The right steels, used in the right place, equip these cars for heavy duty service. Rolled steel construction lengthens their life, cuts weight and consequently reduces operating costs.



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This symbol represents the highest quality, the finest metallurgical service.

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COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Export Company, New York

UNITED STATES STEEL

aluminum, structures, designs and costs. The lectures commence at 8:00 P.M. and are non-technical, easily understood, readily applied and designed to meet the needs of busy practical men. The last four lectures and their dates are as follows:

April 10th—"Factors Influencing the Cost of Welding," by A. E. Gibson, President, Wellman Engineering Co. Place: Room 110, Minnesota Union, University of Minnesota.

May 1st—"Mechanics of Electric Arc Welding."

May 2nd—"Design Factors in Welded Structures."

May 3rd—"Studies of Stresses in Welded Structures, by means of Polarized Light and Rubber Models." The last three lectures will be given by E. W. P. Smith, Consulting Engineer, Lincoln Electric Company. Place: Room 110, Minnesota Union, University of Minnesota.

The committee in charge consists of T. P. Hughes, Chairman, University of Minnesota; C. E. Comfort, St. Paul Structural Steel Company; G. W. Irwin, Air Reduction Sales Company; John Mikulak, Electric Machinery Mfg. Co., and John Nelson, Butler Manufacturing Co.

At the regular meeting of the Section held March 12th, Charles H. Jennings, in charge of welding research, Westinghouse Electric & Manufacturing Company, spoke on "Distortion Problems" at the Minnesota Union, University of Minnesota. In his discussion he covered how local heating and cooling often result in distortion of the welded structures and development of residual stresses, also how they can be controlled by proper design practice and welding procedure.

OKLAHOMA CITY

The Oklahoma City Section of the AMERICAN WELDING SOCIETY held its regular March meeting in parlor "A" of the Biltmore Hotel on Friday evening, March 1st. Preceding the regular meeting the Executive Committee and committee members of the Oklahoma City Section honored President George Terry Horton with a dinner. In addition to the honored guest, the speaker of the evening, Mr. F. G. Flocke, of the International Nickel Company, and Mr. Don Leach, of the Chicago Bridge & Iron Company, also attended the dinner. Since the Executive Committee and other committee members of the section pretty well represented a cross section of the 17 different companies and organizations having membership in the section, it is felt that Mr. Horton got a very good idea of the enthusiasm and activities of this group, and, we, of course, got better acquainted with our president.

At 7:45 P.M. Chairman Banks called the open meeting to order and a motion picture, "Modern Metalworking with Oxyacetylene Flame," was shown. This picture was interesting in that it showed animated sections of acetylene torches as well as the actual use of this equipment in cutting and welding. Following the motion picture Mr. O. T. Barnett, chairman of the Program Committee, introduced President Horton who made a short talk to the group telling of his early connections with the Welding Society and his ideas in connection with the various codes.

Mr. F. G. Flocke, Research Engineer of the International Nickel Company, was next introduced by Mr. Barnett and talked on "Welding of Monel, Nickel, Inconel and Nickel-Clad Steel." Mr. Flocke's address was illustrated by slides and was received with considerable interest by the group.

There were 60 members and guests present at this meeting.

As a part of the work along educational lines the Educational Committee, headed by Mr. Wm. Tiffin of the College of Engineering, University of Oklahoma, was successful in bringing Mr. O. E. Trentham, Service Engineer of The Linde Air Products Company, Denver, Colorado, to Oklahoma City for an address on Wednesday evening, Feb. 14th, on "A Résumé of Oxyacetylene Welding Applications." Mr. Trentham, with the use of colored slides which brought out many interesting details, described bronze welding and discussed such pertinent things as flame hardening, shape cutting, plate edge preparation, cast-iron welding, etc. He told of many interesting experiences in connection with welding of large gear wheels, fly wheels and the piercing of heavy plate with a lance, which was interesting to the group since the operation covered the practical side of welding and cutting.

There were 89 present at this special meeting.

PHILADELPHIA

The April meeting of the Philadelphia Section will be held on the 15th. Welding in Marine Industry will be presented by a representative of the American Bureau of Shipping.

On May 20th it is planned to have an inspection trip to one of the very large manufacturing plants.

PITTSBURGH

One hundred and fifteen members and guests attended the February 21st meeting of the Pittsburgh Section in the Mellon Institute of Industrial Research to hear Mr. William B. Nicholson deliver his talk on "Flame Treating."

It was without doubt the most thorough and complete paper on this subject that has been heard to date. In addition to his talk, Mr. Nicholson showed many slides which clearly brought out the points he made in his talk. He also had with him many samples of flame treating both hardening and softening which proved of considerable interest to many of those present.

Following the talk by Mr. Nicholson a moving picture was shown on flame hardening gears and other products. This picture clearly showed the method used for flame treating and brought out in very accurate detail just how the work was done.

Following the talk and showing of pictures Mr. Nicholson was kept busy for about an hour answering questions from the members and guests present.

The Third Tri-State Conference of the Pittsburgh Section will be held Friday, April 26th, in the Cardinal Room of the Hotel William Penn, jointly with the Engineers' Society of Western Pennsylvania. Following is the program as outlined by the committee on arrangements:

Morning—Plant visitation to the Dravo Corporation, Neville Island, for an inspection of shop and yard facilities. If possible the Dravo Corporation has promised a launching of a welded barge to climax the trip. Following this a lunch will be served in the new Cafeteria.

Afternoon—Technical Session. "Distortion Problems," by C. H. Jennings, Westinghouse Electric & Mfg. Co. "Low Alloy Steels for Welding" by Dr. A. B. Kinzel, Union Carbide & Carbon Co. "Modern Welded Structures" by H. W. Lawson, Bethlehem Steel Corp.

Evening Session—"The AMERICAN WELDING SOCIETY," by W. Spraragen, Technical Secretary and Editor, A. W. S. Guest Speaker: George T. Horton, President, AMERICAN WELDING SOCIETY, and President, Chicago Bridge and Iron Co.

ROCHESTER

The Rochester Section held its regular monthly meeting on March 11th at Todd Union, University of Rochester, River Campus. Dinner preceded the meeting. The speaker of the evening was Mr. J. J. Vreeland, Metallurgical Engineer, Chase Brass & Copper Company, whose subject was "Welding of Copper and Its Alloys."

ST. LOUIS

A joint meeting with the Engineers' Club was held on March 14th in the Engineers' Club Auditorium. Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp., presented an interesting address on "Welded Joints—When to Use Them and Why, and When Not to Use Them and Why Not." The subject, illustrated with slides, was treated from the standpoint of the designer confronted with the necessity of deciding which of the many different kinds of welded joints he should use, not only from the standpoint of strength and integrity but also from the standpoint of cost.

WESTERN NEW YORK

The February meeting of the Western New York Section was held on the 15th in the Electric Building Auditorium, Buffalo, N. Y. The speaker was Mr. John J. Crowe, Manager, Apparatus Research and Development, Air Reduction Sales Company. His subject was "Flame Cutting and Flame Heat Treatment of Steel." There was an attendance of 60 people who heard a very interesting talk and saw some slides and movies covering the subject matter.

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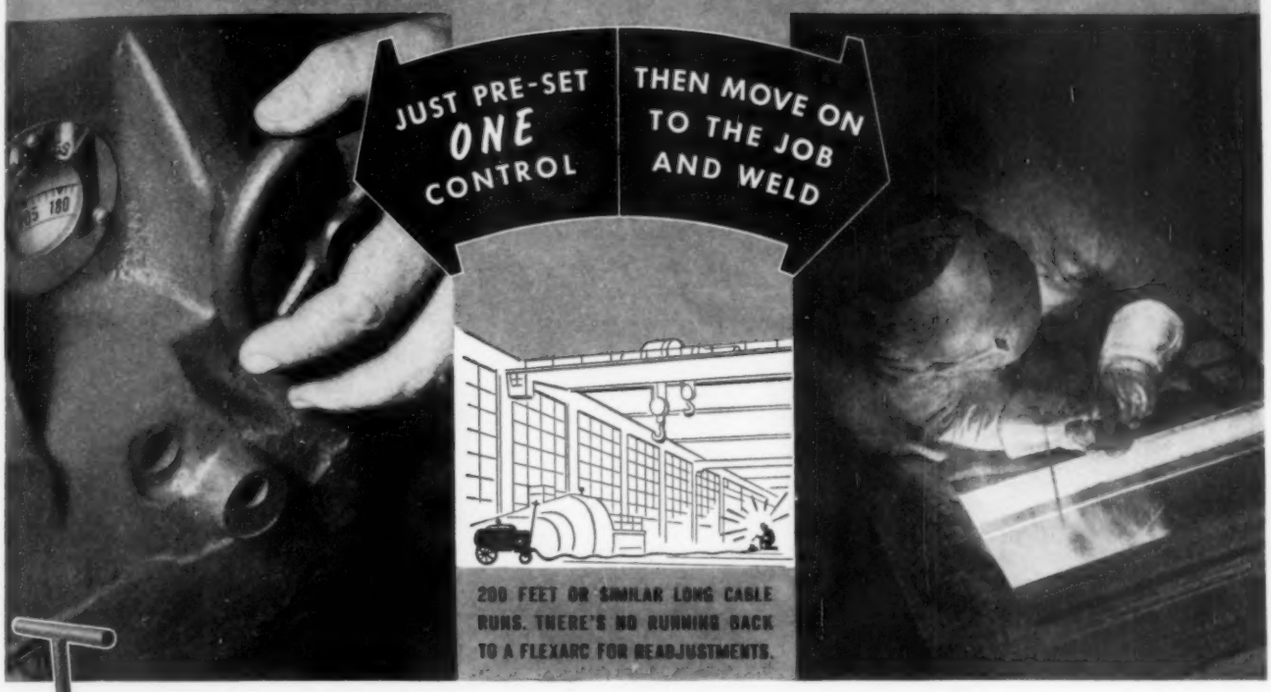
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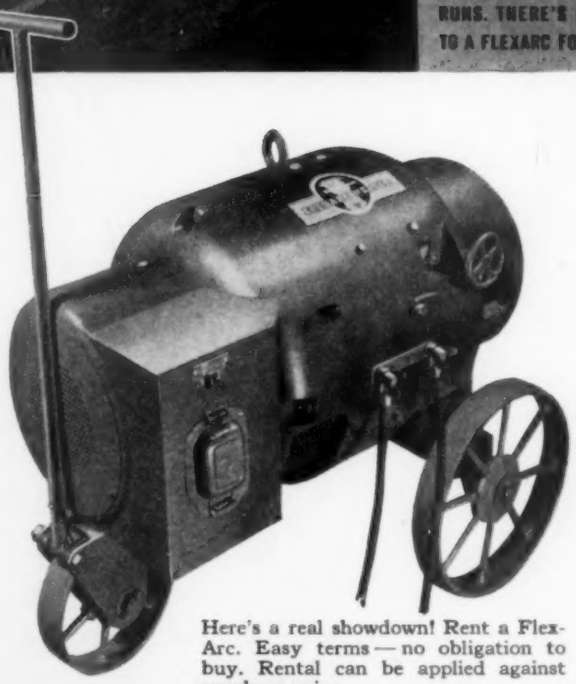

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Here's the capacity to lay metal faster than you ever did before—to spend 60 seconds of every minute welding, not walking—to make better welds because the arc is always right. Isn't that exactly what you want in a welder? . . . then try the 200-FOOT TEST.

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YORK-CENTRAL PA.

Mr. W. D. Halsey, Assistant Chief Engineer, Boiler Division, Hartford Steam Boiler Inspection and Insurance Company, gave a most interesting and enlightening talk on "The American Welding Society's Standard Qualification Procedure" at the February 10th meeting of the York-Central Pennsylvania Section. There were around 100 present and Mr. Halsey was kept busy for thirty or forty minutes after his talk answering questions from the floor.

List of New Members

February 1st to February 29, 1940

BOSTON

Stevens, Malcolm S. (C), Mass. Inst. of Tech., Cambridge, Mass.
Sullivan, Raymond E. (D), 65 Lonsdale St., Dorchester, Mass.
Wolk, Benjamin (D), 91 Nightingale St., Dorchester, Mass.

CANADA

Brown, James S. (B), 10 Westbrook Ave., E. York, Toronto, Canada.
Charette, Paul (C), 7051 Delanaudiere St., Montreal, Que., Canada.

CHATTANOOGA

De Haven, W. A. (C), Combustion Engineering Co., Chattanooga, Tenn.
Moore, R. Taylor (C), P. O. Box 827, Chattanooga, Tenn.

CHICAGO

Morgan, Clifford E. (C), C. M. St. P. & P. R. R., Chicago Union Station, Chicago, Ill.
Walters, Edward (C), % Air Reduction Sales Co., 3100 S. Homan Ave., Chicago, Ill.

CLEVELAND

Auringer, J. A. (B), 9807 Clifton Rd., N. W., Cleveland, Ohio.
Fowles, L. A. (B), The Brush Beryllium Co., 3714 Chester Ave., Cleveland, Ohio.
Little, W. O. (B), 3109 Mayfield Road, Cleveland, Ohio.
Loftfield, Sigurd (C), 19421 Ormistor Ave., Euclid, Ohio.
Priest, Vernon C. (D), 14110 Lorain Ave., Cleveland, Ohio.
Schaub, Carl M. (C), Williams & Co., 3700 Perkins Ave., Cleveland, Ohio.

COLUMBUS

Hanes, Walter W. (C), 1682 W. Mound St., Columbus, Ohio.
Magnelli, Patrick (C), 1212 E. 15th Ave., Columbus, Ohio.
Romeo, Frank (C), 99 E. 11th Ave., Columbus, Ohio.
Slicer, Harry A. (C), 2821 Bremen St., Columbus, Ohio.

DETROIT

Hoover, Joseph C. (C), Wabash Hotel, Detroit, Mich.
Nelson, George P. (B), L. A. Young Spring & Wire Corp., 9200 Russell St., Detroit, Mich.
Sievers, Max. A. (C), Expert Welding Machine Co., 17144 Mt. Elliott Ave., Detroit, Mich.
Swart, C. (B), National Stamping Co., 630 St. Jean Ave., Detroit, Mich.

GEORGIA

Lee, H. J. (D), 834 Cascade Ave., S. W., Atlanta, Ga.
Patrick, A. K., (D) 437 Kelly St. S. E., Atlanta, Ga.

HAWAII

Johnston, Robert (C), P. O. Box 187, Aiea, Oahu, T. H.
Nishimura, Kenichi (D), Honolulu Plantation Co., Aiea, Oahu, T. H.
Sudo, Kenichi (D), P. O. Box 111, Aiea, Oahu, T. H.

INDIANA

Davidson, Thos. (C), Davidson Elec. Mach. Works, Sullivan, Ind.

LAKE SHORE

Beyer, Gilbert G. (C), Optenburg Iron Works, P. O. Box 144, Sheboygan, Wis.
Biever, E. J. (B), Kohler Co., Kohler, Wis.
Boettner, Fred. W. (C), 1603 Ill. Ave., Sheboygan, Wis.
Burger, Walter W. (B), P. O. Box 27, Manitowoc, Wis.
Busse, Marvin H. (C), Optenburg Iron Works, P. O. Box 144, Sheboygan, Wis.
King, Robert E. (C), 1308-A Hamilton St., Manitowoc, Wis.
Christenson, Ray (B), 22 North C. St., Sturgeon Bay, Wis.
Hansel, Joseph (B), J. J. Stangel Hdwe. Co., Manitowoc, Wis.
Herbst, Fred, Jr. (B), 923 Commercial St., Manitowoc, Wis.
Huchthausen, Walter C. (B), The Huchthausen Co., 8th & Washington St., Manitowoc, Wis.
Miller, Niels C. (B), Miller Elec. Mfg. Co., Appleton, Wis.
Olsen, L. B. (B), 1517 Torrison Dr., Manitowoc, Wis.
Pitz, A. L. (B), 820 N. 12th St., Manitowoc, Wis.
Steel, Adam, Jr. (C), 829 Lincoln Blvd., Manitowoc, Wis.
West, John D. (C), R. 2, Manitowoc, Wis.
Wiemann, Albert W. (C), 1418 Oakland Ave., Sheboygan, Wis.
Wirtz, Wm. (D), Kohler Co., Kohler, Wis.
Wolter, Wm. J. (C), Sturgeon Bay Shipbldg. & D. D. Co., Sturgeon Bay, Wis.

LOS ANGELES

Butz, W. H. (B), 3161 California St., Huntington Park, Calif.
Frishholz, C. E. (B), Shell Oil Co., P. O. Box 728, Wilmington, Calif.
Gignoux, J. R. (B), Shell Oil Co., 1008 W. 6th St., Los Angeles, Calif.
McBride, G. B. (D), Rt. 1, Box 180, Lomita, Calif.
Thomas, William J. (D), 606 Acacia Ave., Torrance, Calif.

MILWAUKEE

Downing, Donald R. (C), 945 N. Jefferson St. Apt. 35, Milwaukee, Wis.
Kraetsch, Elmor (D), 728 N. 14th St. Apt. Q, Milwaukee, Wis.

NEW YORK

Braisted, M. V. (D), 9309 — 209th St., Queens Village, L. I., N. Y.
Duffy, Wm. J. (D), 7835 — 65th St., Glendale, L. I., N. Y.
Lee, Leonard (D), 425 Senator St., Brooklyn, N. Y.
Lunstrom, James E. (D), 82 Randall Ave., Elmont, N. Y.
Jarolim, Frank (D), 1526 First Ave. New York, N. Y.
Pytel, Frank B. (D), Box 6, So. River, N. J.
Seemann, Arthur K. (B), Linde Air Prods. Co., 30 E. 42nd St., New York, N. Y.
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Soman, Robert (C), 9318 Baldwin Ave., Forest Hills, N. Y.
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Bennett, Morris, (D) 55 Chestnut St., E. Orange, N. J.
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Katzen, Bernard (D), 57 Lillie St., Newark, N. J.
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Kobus, Peter (D), Dall Ave., Keasby, N. J.
Krouza, Louis (D), Box 156-D—R. F. D. 1 George St., E. Rahway, N. J.
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Osoliniec, Edward (D), 46 Hensler St., Newark, N. J.
Paccioretti, John (D), 7 E. Clifton Ave., Clifton, N. J.
Peluso, Fred (D), 6 Hamilton Pl., Clifton, N. J.
Peterson, Clyde (D), Bloomfield Ave., Pine Brook, N. J.
Mikkelsen, Niles (D), % National Inst., 93 Lafayette St., Newark, N. J.
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Rosienski, Stanley (D), 224 Fulton St., Elizabeth, N. J.
Shapinski, Joseph (D), 418 So. 8th St., Newark, N. J.

Steffins, John H. (D), 292 Elm St., Kearny, N. J.
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Trefts, George M., 3rd (C), Farrar & Trefts, Inc., 9 Grimes St., Buffalo, N. Y.
Tuck, J. H. (B), Whitehead Metal Prods. Co. of Canada, Port Colborne, Ont., Canada.

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Brunson, Harry S. (C), 698 Hawthorne St., St. Paul, Minn.
Flansburg, Claude (D), 4240 Adair Ave., Robbinsdale, Minn.
Huna, A. L. (C), Air Reduction Sales Co., 327—25th Ave. S. E., Minneapolis, Minn.
Williams, Roy E. (D), Deephaven Park, Rt. 2, Wayzata, Minn.

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Bunch, Jim E. (F), 624 West St., Stillwater, Okla.
Jones, Robt. C. (F), Box 32, Stillwater, Okla.
Lang, J. L. (C), 718 N. W. 32nd St., Oklahoma City, Okla.
Phariss, Tom (F), 813 W. 4th St., Stillwater, Okla.
Presnall, Robert H. (F), Box 32, Stillwater, Okla.

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Johnson, Bert C. (D), 608 Tracy, Peoria, Ill.
Miller, R. O. (D), 428 Peoria Ave., Peoria, Ill.

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Laur, Anna A. (D), 25 Price St., Philadelphia, Pa.
Terry, Willard A. (C), General Elec. Co., 1405 Locust St., Philadelphia, Pa.

PITTSBURGH

Chyczewski, E. B. (D), 624 Beacer Road, Ambridge, Pa.

PUGET SOUND

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ST. LOUIS

Rebsamen, William (D), 2848 Pestalozzi St., St. Louis, Mo.

SAN FRANCISCO

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Bacon, R. R. (B), Shell Oil Co., Martinez, Calif.
Bunnell, J. McDonald (D), 4125 Mariposa Ave., Sacramento, Calif.
Estrada, W. J. (D), 2986—19th St., Sacramento, Calif.
Graham, Walter B. (C), 909 Hilldale Ave., Berkeley, Calif.
Jones, George (D), 2418 Potter St., Oakland, Calif.
Stettner, Fred (B), 179 Estates Dr., Piedmont, Calif.

SOUTH TEXAS

Howard, Frank (D), 4516 Fulton, Houston, Texas.
Moreland, Banks (C), Banks Moreland Co., P. O. Box 1764, Houston, Texas.

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Whitmire, Clyde P. (D), 1726 N. Frankfort St., Tulsa, Okla.

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Bates, James L. (C), Maritime Commission, Washington, D. C.
Cowling, James G. (C), 1001—15th St., Washington, D. C.
Eberhardt, Jacob, Jr. (D), 112—15th St. S. E., Washington, D. C.
Ingram, Harry L., Jr. (C), 1823—L—St. N. W., Washington, D. C.

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Bankert, H. E. (C), Central Iron & Steel Co., Harrisburg, Pa.

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Cook, Roy F. (D), % C. E. Cook, New Deal, Mont.
Pool, James M. (C), Louisville Welding Works, 807 So. First St., Louisville, Ky.
Simon, Werner H. (B), 13 Hunstone Ave., Sheffield 8, England.
Wilder, Leon G. (B), 760 Baldwin St., Elmira, N. Y.
Zornman, W. W. (C), 2236 Shelby St., New Albany, Ind.

UNUSUAL BRAKE APPLICATIONS

Large metal boxes of light gage material may be manufactured at low cost on bending presses. However a problem often encountered is a reverse bend, inadvertently formed in the sheet. This reverse bend is due to a whip in the sheet, which in turn is due to the difficulty of supporting the metal during the action of the press. When done by hand, work of this kind requires skilled operators and is often a slow process. The photograph attached shows the manner in which Cyril Bath & Company of Cleveland, Ohio, manufacturers and distributors of bending presses and special machinery, have met this problem in forming the inner liner of the typical refrigerator. The sheets are first blanked and then formed on bending presses. The photograph shows the bending of the straight-flanged sheet into the desired box section. This is done by a special fixture which supports the metal during the process of bending, the gaging being done from holes already punched in the sheet for other purposes. The die is a triple-action die, and the flanges are taken around the corner smoothly by special spring-die arrangement. The raising or supporting arms prevent the occurrence of reverse bends and put the operation on a production basis. The work is being done in a Sturdybender weld press, with overhung bed and ram on each end, so that with two operators a completed box is finished and ready for the back to be welded at better than 80 an hour.

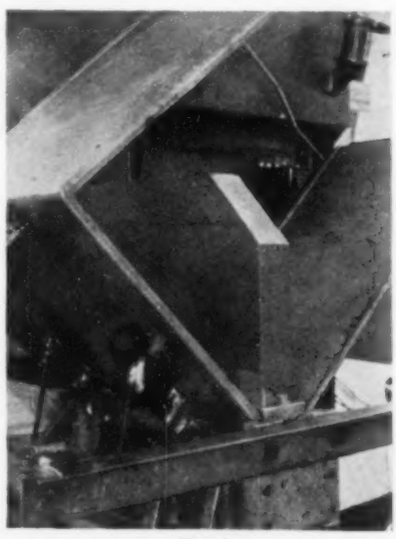


Fig. 1

A secondary problem is also illustrated by this operation. It is frequently desirable to make boxes with flanged edges without cutting out the corners, and this can be done by making the corners of a larger radius instead of a sharp corner, as is done on the front edge of the cabinet shown. The back edge has a developed notch in it, because the back is welded over the flange at this point. This process avoids a costly welding and hand-finish operation on the front flange. Because hand-finishing operations in sheet metal have a cost out of all relation to their significance, a device of this kind may well show a quite surprising cost reduction. The principle is applicable to any production problem where the handling of the work causes reverse bends, or where the work is a source of danger to the operators when so handled.

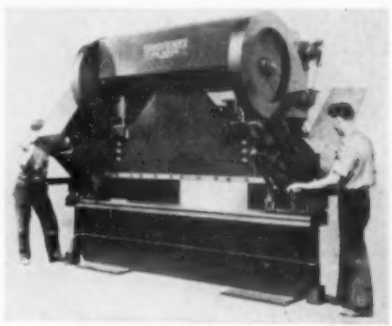
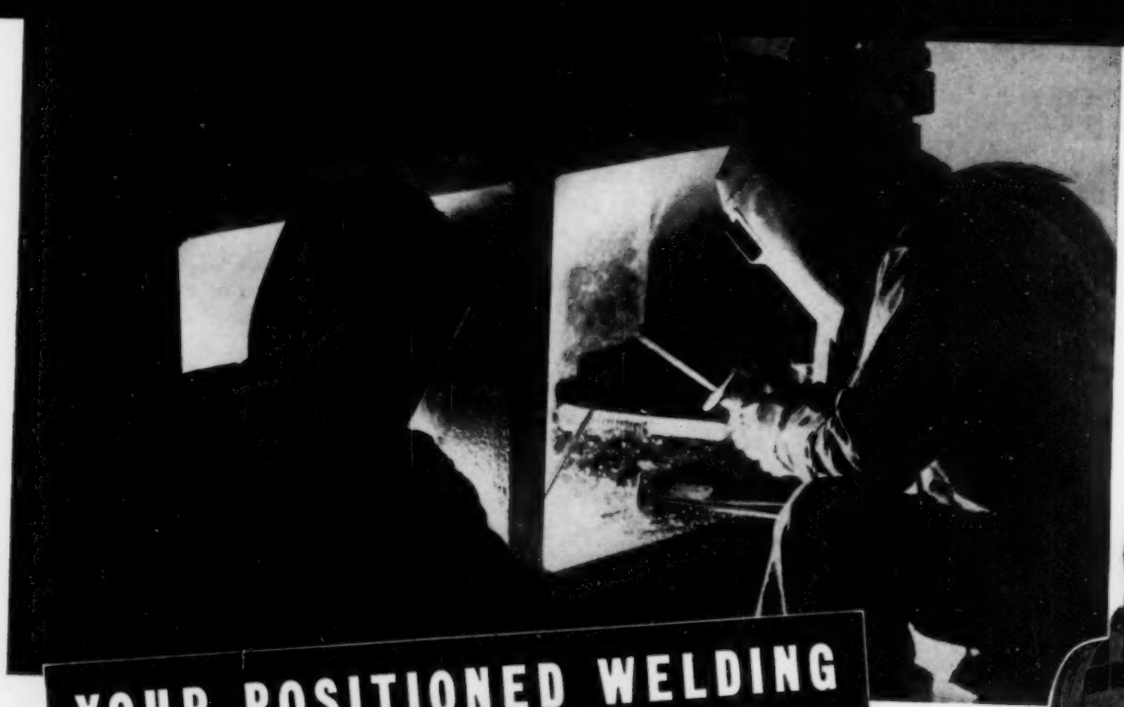


Fig. 2

SILVER BRAZING ALLOYS IN THE MARINE FIELD

A very attractive technical pamphlet on the above subject, prepared by R. H. Leach and Leo Edelson, is being distributed by the Handy & Harman Co., 82 Fulton Street, New York. This book is available on request. The principles of brazing considered in connection with marine work apply with little or no variation to any work where low-temperature silver brazing alloys are to be used. Therefore this article should be of interest to all who join ferrous or non-ferrous metals.



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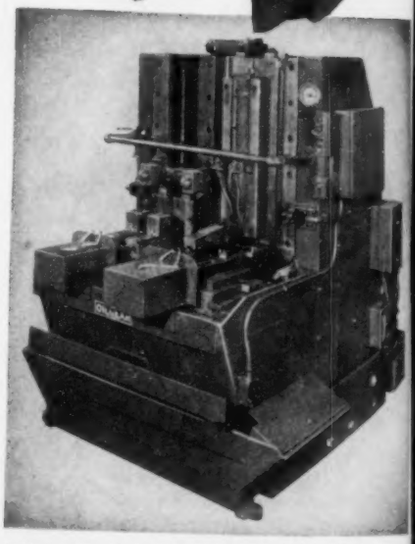
Type FHP welds stand the gaff in equipment such as these ingot stripping tongs made by Shaw-Box Crane & Hoist Co., Muskegon, Mich.



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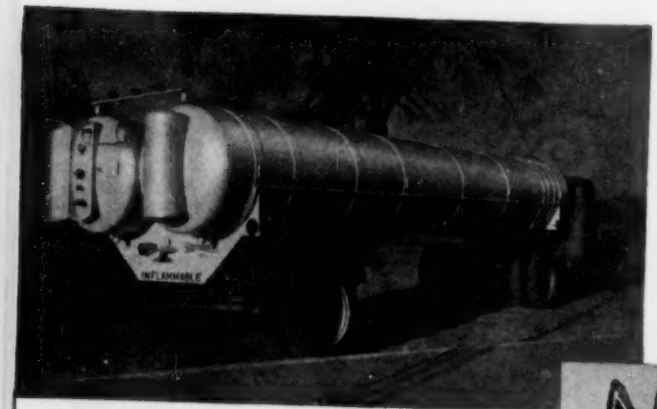

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